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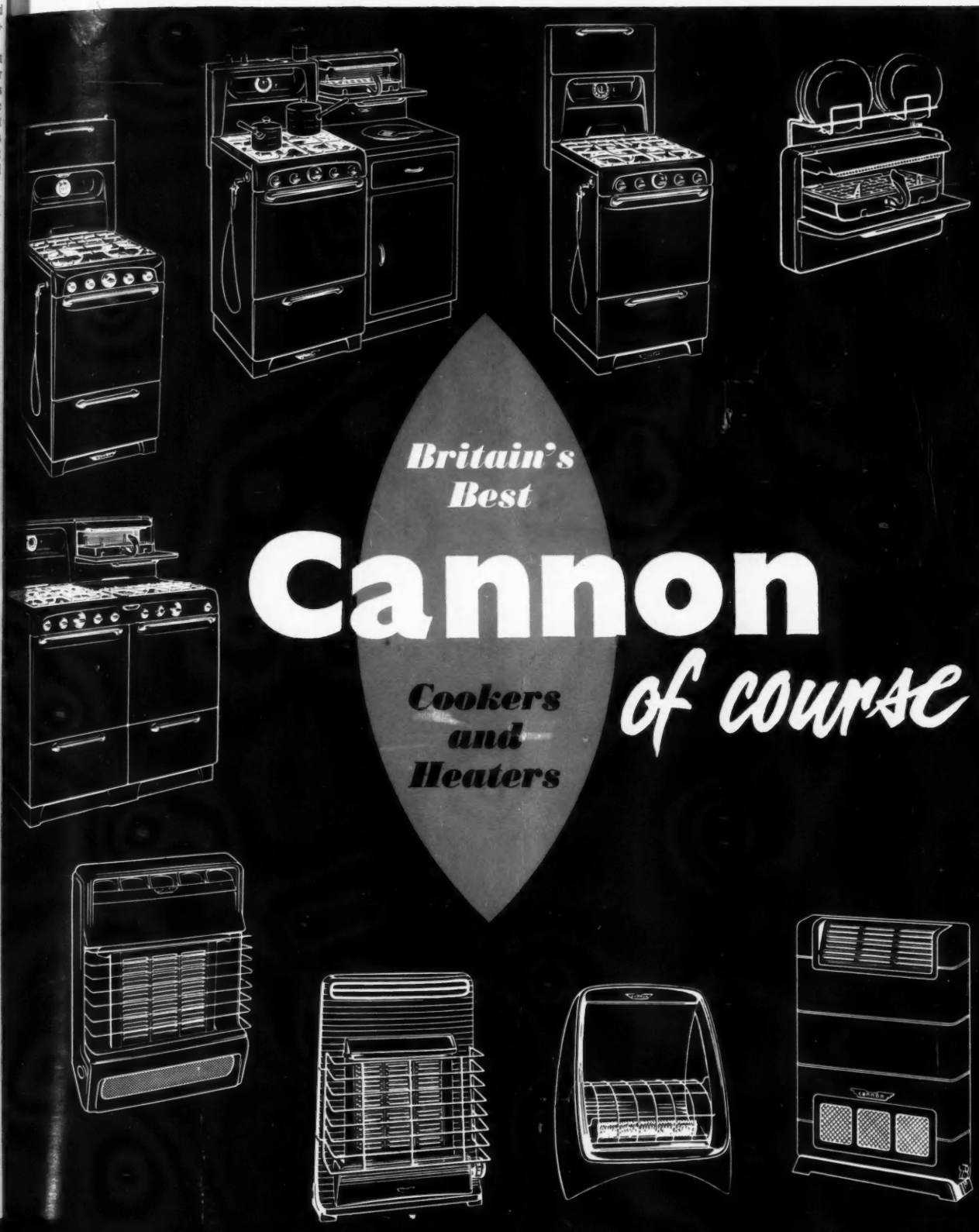

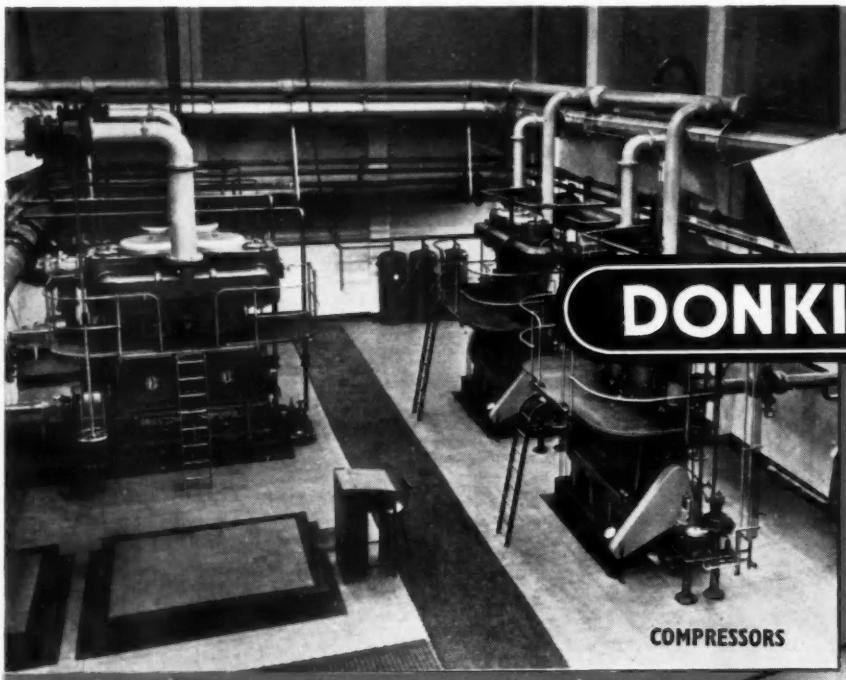

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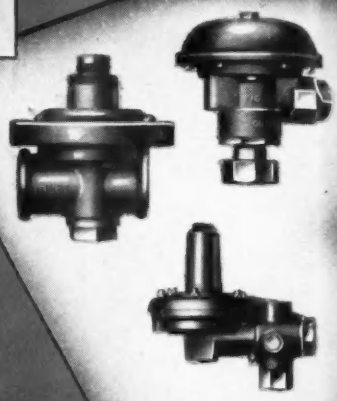

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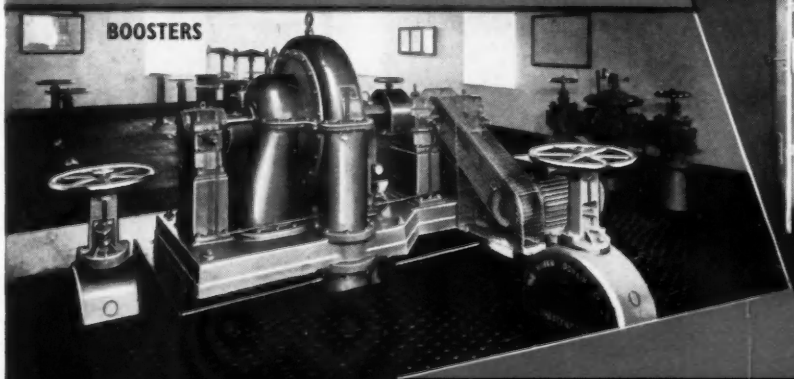

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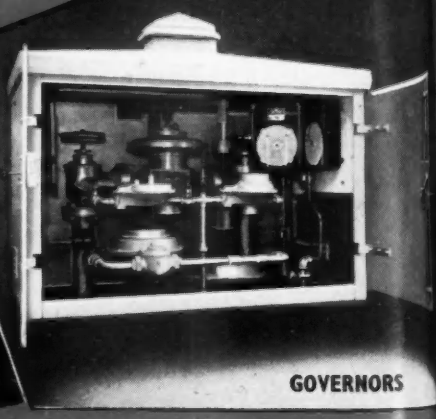

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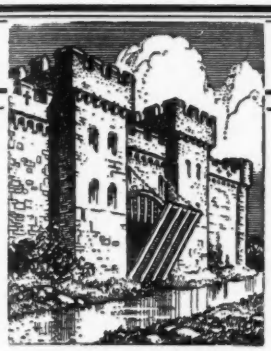

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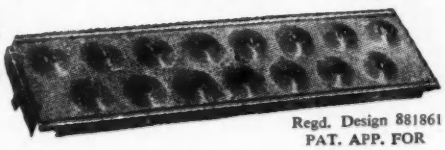

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Gas Journal

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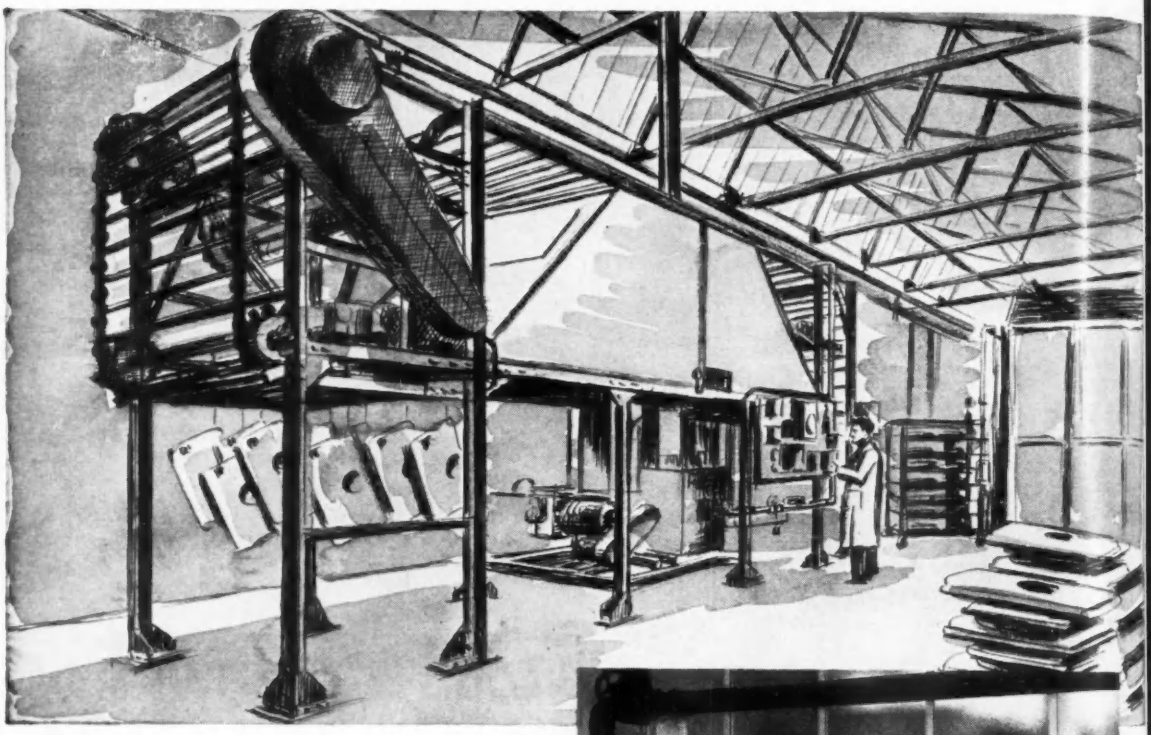

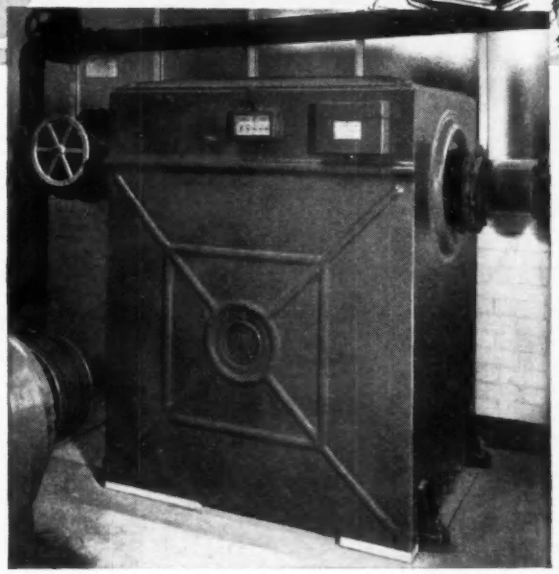

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Gas Journal

VOLUME 297. No. 4989 FEBRUARY 25, 1959. 111th YEAR

Effluent: Bacteria to the Rescue

THE problems facing our sister industry, the coking industry, are in many cases similar to our own, except that they are generally on a larger scale. This is only because most coking plants have a considerably greater daily coal throughput than the average gasworks. The disposal of effluent liquor is, therefore, generally an even greater problem for the modern coke oven plant than it is for the gas industry. We have taken up this point on several occasions in the past and have discussed the courses open to the carbonising industries. The large works can perhaps make the manufacture of ammonium sulphate pay, while the smaller works, the medium-sized gasworks, for instance, will rely on the manufacture of concentrated ammonia as a means of getting rid of liquor. The very small works, most of which are fast disappearing, will still perhaps be able to dispose of its crude liquor direct to the local sewers.

In the past we have referred to plants now in existence to render this material innocuous before it in turn finds its way into the local sewers or even into some nearby waterway. These plants were based on chemical action between the toxic constituent and some added reagent, but up till now only passing reference has been made to the biological treatment of spent liquors.

In a most interesting paper on 'Factors Affecting Biological Treatment of Carbonisation Effluents,' read to the Southern Section of the Coke Oven Managers' Association at Cardiff recently, Dr. J. W. Abson and Mr. K. H. Todhunter describe experiments they have carried out to investigate the possibilities of rendering harmless by biological means, toxic constituents, including ammonia itself, contained in effluent liquors. From these experiments the treated liquor would appear to have had these constituents reduced to such a point that no harm to fish or aquatic life would result if it was allowed to flow into rivers. Although the authors have worked out this process, studying each step in great detail, no full-scale plant has yet been built.

A great deal of work has been done on this means of effluent treatment in the past, both in this country and on the Continent by the gas and coking industries, but much of it was carried out in the presence of sewage sludge—that is to say, after the liquor had arrived at the sewage treatment works. But it was considered possible to treat it by biological means at the gasworks before disposal. Among those who put forward ideas for treatment at this stage was Mr. E. H. M. Badger, of the London Research Station of the Gas Council, in a paper to the Autumn Research Meeting of the Institution in 1955. One of the difficulties to be overcome is the acquisition of suitable bacteria to undertake the three processes involved and to keep them alive and active. Special bacteria are needed for the disposal of the phenol, the oxidation of the thiocyanates and the final oxidation of the ammonia, still contained in the spent liquor. Since each breakdown process interferes with the other, each biological treatment has to be carried out in turn, in the right order and in the correct type of vessel. Food in the form of certain inorganic salts must be added to the effluent just prior to treatment to keep the bacteria alive. Correct conditions of acidity and temperature must be found and carefully maintained at the optimum. The presence of certain metallic ions in the effluent may have an adverse effect on the working of the bacteria. Since this affects the material of construction of the plant in which the process is carried out, the authors have gone to great pains to find out the relative effects of a number of metals to find a suitable constructional material.

The products of the reactions have been carefully studied and their effects on the working of the bacteria noted, so that steps can be taken to neutralise any adverse influence on the *p*H value of the reaction solutions. The authors also describe in some detail the most suitable bacteria needed for each stage, and how these have been isolated and made available.

Since the composition of carbonisation effluent varies so greatly from one works to another according to the

type of plant used and the type of coal carbonised, an exhaustive investigation was carried out by the authors to measure the effect on the bacteria of the commonly found constituents other than those actually being treated. Such an investigation, though probably time consuming, is, we think, of the utmost value, because in the past there was often a tendency to think that if some liquors worked satisfactorily while others did not, this type of process was not universally applicable. Such baffling inconsistences may often be explained by the extra knowledge of the process given by this type of research.

The bacteria are, however, remarkably accommodating provided their needs of food and oxygen—all these bacteria are aerobic—are met. In some cases adverse conditions are accepted by the bacteria; their activity, though temporarily checked, was often resumed after a lapse of time.

We consider this paper to be one of major importance, since it would seem to hold the solution to a most pressing problem facing both carbonising industries. We have pointed out recently that effluent is a costly waste product to dispose of to the satisfaction of all concerned. The treatment plants now in use and depending on pure chemical means, are costly to operate. Although many have accepted this fact as a necessary evil, it is galling for the gas engineer when he realises that this is a manufacturing cost imposed upon him from outside by a most necessary and reasonable regulation enforceable by law. If the process now under review proves to be cheap to operate—it is a pity that the authors did not give any estimated costs for running a full scale plant—the liquor disposal problem may well become a thing of the past.

The activities of the different sections of the Coke Oven Managers' Association are of very great interest to all those in the gas industry interested in carbonisation, however different the immediate problems may be. The differences are largely of degree rather than of kind, and this is borne out by the ever increasing exchange of views taking place between the two professional bodies as shown by the annual joint meetings arranged by the Institution and the Association to discuss technical points of mutual interest. It was of particular interest that this paper should have been read to the Southern Section at Cardiff, because it was in South Wales that so much work on liquor disposal was carried out by Mr. R. J. Barritt, the former Carbonisation General Manager of the South Western Division of the National Coal Board.

The French 'Journal'

THE January number of our French contemporary appears with a new title. The *Journal des Usines à Gaz* becomes the *Journal des Industries du Gaz*. The emphasis moves from the gasworks to the other sources of gas supply and the whole range of allied industries.

It was only after many consultations and much hesitation, says the Editor, that the change of name was decided upon. Pointing out that the *Journal des Usines à Gaz* was born in 1877 and has thus entered upon its 83rd year, making it one of the oldest French technical papers, he remarks: 'We appreciate all the honour of this long life, but at the same time we wish to avoid the wrinkles of age.' Gasworks are being shut down one after another and in a few years there will remain only the few large central works. The new title indicates that the new journal will interest itself not only in manufactured gas but in the transmission, distribution and utilisation of all the gases now available. Further, the 'classic' gas industry has a community of interest with many other industries, as for example with the petroleum industry of which it consumes certain products in ever-growing quantities, and with the production of natural gas.

It is equally closely associated with the constructors of gasworks plant who in recent years have been driven to depart from traditional ideas and to adapt themselves to the invention of the oil-cracking apparatus now so widely coming into use over the whole world. Gas transported over long distances and at high pressures has given rise to a whole new range of apparatus. The rapidity with which Gaz de France has been compelled to lay thousands of kilometres of transmission mains has led to a vital interest in the production of steel tubes and to many problems in their protection and installation. There is also the whole field of the design and construction of apparatus for the utilisation of all the gases now available, particularly in the industrial market where the possibilities opening up today would have appeared unimaginable a short time ago.

The editorial continues: 'It seems, therefore, natural to range our journal, the only one in its field, under the general expression of 'the gas industries.' If the term *Journal* may seem unusual for a monthly organ, we mean by that our publication will, as far as possible, follow the day-to-day problems arising in the whole gas section as this term is used in the international organisations. This is an ambition, not without presumption, which can only be realised with the assistance of all those engaged in the development of that form of energy represented by the combustible gases. No one today doubts that this form of energy is destined in the years to come to a very high degree of expansion, both in this country (France) and in the whole of Europe.'

We feel sure that all our readers will join with us in wishing our French contemporary a long and successful life under its new title.

The 'Methane Pioneer'

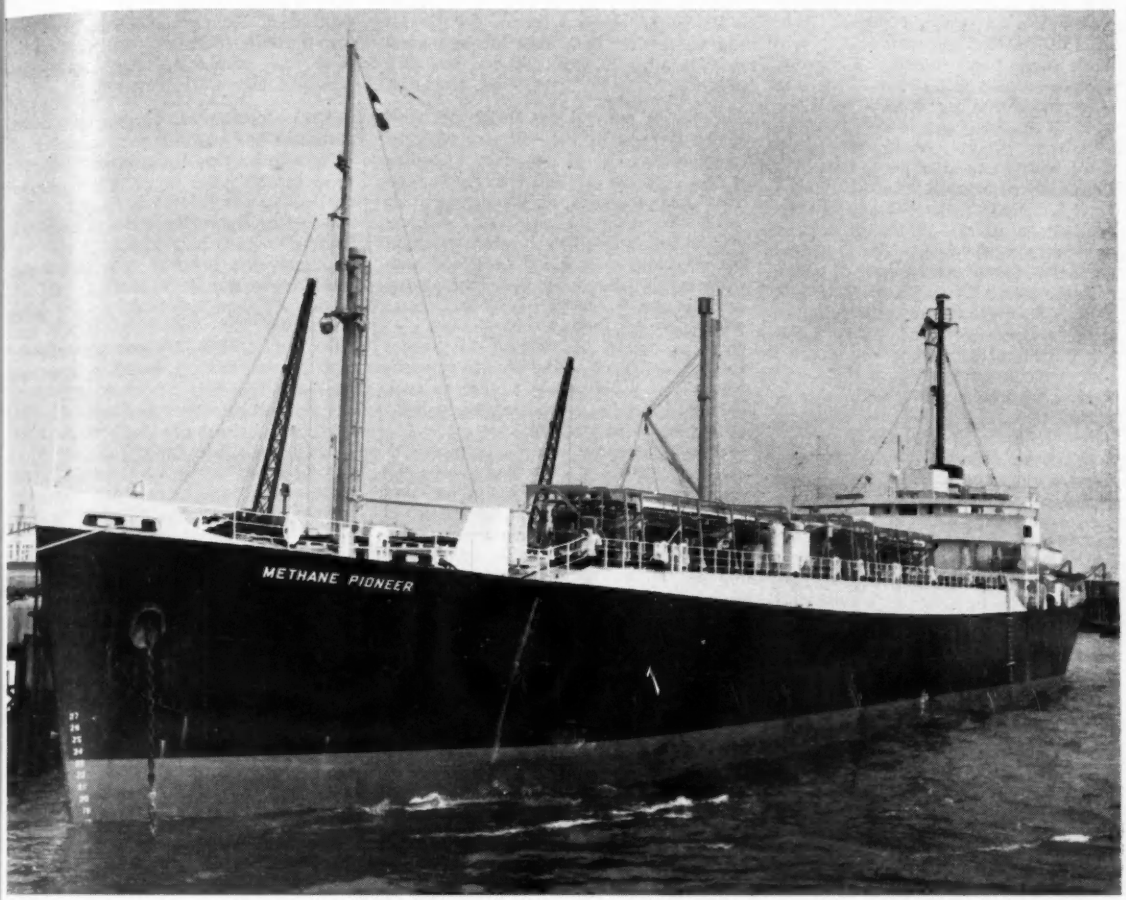
(To be sung briskly by progressive men of gas to the tune of the 'British Grenadiers').

Some talk of Onia-Gegi
And others speak of Shell,
Of Isle of Grain and Fawley
and P.F.D. as well.
But gas that's come across the sea
Will turn out much less dear
With the low CO and the high CV
Of the 'Methane Pioneer.'

The age of coal is rolling
Towards eternal rest;
The passing-bell is tolling
For the plants which Padfield blessed.
Then forward boldly let us go,
Utopia is near!
With the high CV and the low CO
Of the 'Methane Pioneer.'

ANON.

COMPLETION OF THE FIRST STAGE



Arrival of tanker shows methane shipment is feasible

On board the Methane Pioneer, now moored at Canvey Island (see top picture) are pictured, from left to right: Sir Harold Smith, Chairman, Gas Council, Captain J. T. Gibson, in command of the Methane Pioneer, and Mr. Ed. Battson, President of Constock International Methane Inc. (U.S.A.) and Director of British Methane Ltd.

THE arrival of Methane Pioneer at Canvey Island, Essex, with the first load of liquid natural gas ever to be carried by sea, marks the completion of the first stage in an experiment which has attracted worldwide interest. It will obviously be necessary for three or four more trial voyages of this nature to be undertaken before the technical and economic possibilities of this project can be fully assessed. Also, the load which has arrived has still to be transferred to the holder tanks at Canvey Island, reconverted to gas and taken by pipeline to the Romford works of the North Thames Gas Board for reforming before it can be mixed into the town supply. But already the arrival of the tanker has shown that it is technically possible for this gas to be transported over thousands of miles of ocean in liquid form at a temperature of minus 260°F.

Net value to gas industry

The experimental load consists of 2,000 tons of liquid natural gas which came from one of the Gulf Coast oilfields. Natural gas in its original state is estimated to have an equivalent of approximately 530 therms per ton. Allowing for losses during the conversion processes and during the voyage it is estimated that the net value to the gas industry will be approximately 480 therms per ton. If the trials prove successful, both from the technical and economic points of view, consideration will be given to the import of liquid methane on a much larger scale. Vessels carrying some 30,000 tons will probably be required in order to secure real economy.

Personal

MR. R. D. COOK has been appointed representative of Morley Products (Padiham) Ltd., in the Eastern and North Thames Gas Board areas. Following service with the Royal Air Force in North Africa and the Middle East, he was, for a time, engaged in civil aviation. He has since gained considerable experience of selling and sales promotion with the nation-wide organisations of J. Lyons & Co. Ltd. and T. Walls & Sons Ltd. Mr. Cook will be taking over in the eastern area from MR. G. L. EDWARDS, who is being transferred to an associate company and in the North Thames area from MR. J. W. SAXON, who in future will be representing the company in the Southern and South Eastern areas.

MR. ALBERT WHITFIELD takes over as General Manager of Widnes Foundry & Engineering Co., Ltd., Lugsdale Road, Widnes, from March 1. He was appointed a director in 1955. He joined the company in 1938 and became Works Manager in 1949. The retirement from active duties of the Joint Managing Director, Mr. Ralph Credland, is also announced. Mr. Credland will remain on the board of directors in a consultative capacity.

MR. S. C. WATSON, of Hexham (Northumberland), Sales Manager for the Tyneside Division of the Northern Gas Board, is to receive a presentation to mark his forthcoming retirement.

MR. S. WATTS, chief draughtsman of Sir W. H. Bailey & Co., Ltd., has been appointed Chief Engineer (Contracts Division) and MR. B. SCOTT-GARRETT has joined the company as Chief Engineer (Control Division).

NEW £1 MILL. FUEL OIL TERMINAL

A NEW ocean-fed terminal, costing over £1 mill. is being built by Mobil Oil Co., Ltd., at Ellesmere Port, in Cheshire. Facilities will be provided for the storage and distribution of a full range of petroleum products. It is hoped to have the installation completed by the autumn.

The marketing of industrial and domestic Mobil fuel oils will be undertaken by Charrington, Gardner, Locket and Co., Ltd., one of the country's largest fuel distributors, who are already the sole distributors of Mobil fuel oils in a wide area embracing London, East Anglia, and the Midlands.

The main contractors are John Laing & Son Ltd., who, as far as the mechanical and electrical work is concerned, are in association with the H. K. Ferguson Co., of Great Britain Ltd.

George Cohen dividend

The George Cohen 600 Group Ltd., have declared an interim dividend of 4½%, less tax, on ordinary shares for the year ending March 31, 1959, on that date.

Obituary

MR. ROBIN WILSON, who was representative in the North West for the Parkinson Stove Co., Ltd., until his retirement in 1951 after 29 years' service, has died aged 72.

A friend writes: Mr. Robin Wilson's many friends in the industry will be saddened to read of his death. Coming from a 'gas' family (his father was engineer and manager at Coatbridge), his whole life—after the early years and service in the 1914-18 war—was spent on the appliance side, which he served with single-mindedness. A man of many qualities, he will perhaps be best remembered for his almost unique and unswerving loyalty to his firm, to the gas industry in general, and to his personal friends. In good and bad times he took a balanced view of passing events; his advice and help was often sought in unexpected quarters. Many a youngster at the start of his career had cause to remember his kindness. Robin was one of the old school and a character in his own right. Like all good representatives he had a few gimmicks and none of those who knew him will forget the huge pipe, the square-toed shoes polished like a mirror, and on special occasions, the deerstalker hat. 'Accused' of being a Scot he would sorrowfully shake his head, admit the soft impeachment, and add 'but I've lived it down.' In his element at social functions, many will remember his happy and cheery presence after Institution meetings, B.I.F.'s, and other gatherings. Though latterly in much impaired health, following a series of operations, he carried on with remarkable courage and cheerfulness.—A. K.

MR. DAVID MUIR, engineer and manager of the Pontypridd undertaking of the Wales Gas Board until his retirement in 1957, has died. His service to the gas industry totalled 51 years. He was at Gratham, Tyldesley, Grays and Seaford, before taking the appointment at Pontypridd in 1929. Mr. Muir was president of the Wales and Mon. Association of Gas Engineers in 1943 and was a past chairman of the Wales Gas Salesmen's Circle. He was deputy chairman of the East Glamorgan Group of the Wales Gas Board until his retirement and was chairman of the Llantrisant Gas Company before nationalisation. Soon after his arrival in Pontypridd, Mr. Muir contracted to take a bulk supply of gas from the Maritime coke ovens and thereby pioneered the first link in what was to become the Wales Gas Board's scheme of integrated gas supply. Two of Mr. Muir's sons are well known in the gas industry; Mr. David Muir, Area Manager for Meters Ltd., and Mr. Kenneth Muir of the Wellington Tube Works Ltd. Among many ex-colleagues and friends who attended the funeral was Mr. E. M. Edwards, President of the Institution of Gas Engineers, who had known Mr. Muir for over 30 years.

Diary of forthcoming events

March 3.—SOCIETY OF CHEMICAL INDUSTRY: Chemistry Lecture Theatre, University of Leeds. 'Interaction of Some Gases at the Surface of Metals,' by Dr. F. C. Tomkins. 6.30 p.m.

March 4.—INSTITUTE OF FUEL, YORKSHIRE SECTION: Hull. 'Treatment of Water for the Prevention of Scale and Corrosion, with particular reference to Cooling Water,' by G. T. Peat. 2.30 p.m.

March 4.—SOUTHERN G.C.C.: Civic Centre, Southampton. Council Meeting at 11 a.m.

March 5.—EAST MIDLANDS G.C.C.: Nottingham Chamber of Commerce offices, Smithy Row, Nottingham. Council meeting at 11 a.m.

March 5.—INSTITUTE OF FUEL, MERSEYSIDE SUB-SECTION: 9, The Temple, Dale Street, Liverpool. Annual General Meeting and films by Shell-Mex and B.P. Ltd. 7 p.m.

March 5. — SOCIETY OF INSTRUMENT TECHNOLOGY, DATA PROCESSING SECTION: Manson House, Portland Place, London, W.1. Symposium on the Use of Data Recorded on Industrial Plant. 5.30 p.m.

March 5.—INSTITUTE OF FUEL, BRISTOL AREA: Chemical Department of the University, Woodland Road, Bristol 8. 'Some Aspects of Modern Refinery Operations,' by D. T. Leahy. Joint meeting with the Society of Chemical Industry. 6.30 p.m.

March 6.—SOCIETY FOR ANALYTICAL CHEMISTRY: Burlington House, Piccadilly, London, W.1. Annual General Meeting. 2.30 p.m.

March 6. — LONDON AND SOUTHERN JUNIORS: 'Education and Training for Gas Engineering,' by A. G. Higgins, Assistant Secretary, I.G.E.

March 6.—INSTITUTE OF FUEL, SOUTH WALES SECTION: 'Gas Producers with special reference to South Wales Coals,' by Dr. G. W. G. Allan. 6 p.m.

March 7.—MANCHESTER JUNIORS: Lancashire Cricket Club Pavilion, Old Trafford, Manchester. Annual Dinner and Dance.

March 9.—INSTITUTE OF FUEL, YORKSHIRE SECTION: Queens Hotel, Leeds. Annual Dinner. 7 p.m.

March 11.—EASTERN JUNIORS: Ipswich. Visit to Ransomes, Sims & Jefferies, Ltd.; paper entitled 'Industrial Gas in an East Anglian Division,' by R. F. Saggers.

March 11.—INSTITUTE OF FUEL, NORTH WESTERN SECTION: Midland Hotel, Manchester. Ladies' Evening—Film by Shell-Mex and B.P. Ltd. 7 p.m.

March 11.—SOUTH WESTERN SECTION, I.G.E.: Swindon. 'Power, Light and Water,' by T. W. Clapham. Visit to Swindon Manufacturing Station.

JUNIORS HAVE DISTINGUISHED GUEST

THE President of the Institution of Gas Engineers, Mr. E. M. Edwards, attended a meeting of the East of Scotland Junior Gas Association at Perth earlier this month.

He heard Mr. W. J. Green, area Operating Engineer for the Woodall-Duckham Construction Co., Ltd., present his paper called 'Avoiding Trouble,' which dealt with practical problems encountered by a technical assistant in a retort house. A discussion followed.

Eye to costs

Mr. Edwards, in adding a few words at the close of the discussion, mentioned the value of developing a plan of inspection and doing it thoroughly. An enquiring mind with an eye to costs at all times was a most important attribute. He detailed production ratios that he had found of immense value, and asked members to consider their use in their day-to-day operations. He thanked all present for the welcome he had received and expressed delight at listening to the presentation of a really practical paper.

Mr. Edwards was accompanied by Mr. W. Nicol Baird, General Manager, Central Division of the Scottish Gas Board.

Scottish Board approve £428,213 expenditure on projects

MORE WORKS TO CLOSE WITH INTEGRATION

TWO integration schemes in the south-east of Scotland, together costing £181,100 and involving the closure of well-known producing centres, were reported to a meeting of the Scottish Gas Consultative Council in Edinburgh last week as having been approved by the Scottish Gas Board.

They formed part of a list of approved projects which totalled £428,213. The divisional figures were: Edinburgh and South East, £194,182; Glasgow and West, £135,771; South West, £68,260; Central, £30,000.

The larger of the two projects in the south-east is the Galashiels integration scheme in the Border area. It is costing £109,500 and allows for the laying of grid mains from Galashiels to Innerleithen and from Selkirk to Hawick (over 12 miles in each case), with the provision of compressing plant and governing equipment. A scheme to link Innerleithen and Peebles with the integration project has already been approved by the Board, and its completion will mean that gas production at Peebles and Innerleithen will be discontinued.

In the new section now to be undertaken, Hawick gasworks will be placed as far as possible on baseload gas production, and will supply moderate quantities of gas into the grid system in order to assist Galashiels gasworks to meet the load.

The other south-east integration scheme is in East Lothian, and is also in its second stage. A sum of £71,600 is now to be spent, chiefly on the laying of grid mains and the provision of compressing plant and governing equipment. The first stage of this grid scheme involved the laying of mains from Haddington to Aberlady and from Haddington to East Linton. These sections have been completed and gas production at East Linton and Aberlady has already been discontinued. Gas production at Dunbar, North Berwick and Haddington will be discontinued following the completion of the grid mains now approved.

A small compression station will be established at Prestonlinks holder station for the purpose of supplying the grid mains system, the source of gas supply being from Granton gasworks, Edinburgh, and Musselburgh gasworks (as long as the Musselburgh works continue in operation).

Provan, Dawsholm and Tradeston works in Glasgow are all concerned in the Glasgow and West projects. Modification of existing carburetted water gas plants at Provan and Dawsholm for the purpose of using light gasworks distillate in place of gas oil will cost a total of £55,200. In addition, £10,870 is to be spent on the renewal of railway sidings at Dawsholm. The Tradeston work involves £44,800 in the resetting of No. 1 bench of retorts.

In the Central District twelve retorts in 'C' bench at Dundee are to be reconstructed at a cost of between £30,000 and £35,000.

In the South West District the chief provision is for the laying of mains in several areas, with £17,000 for repairs to settings of continuous vertical retorts at Paisley.

Left to right: Mr. P. G. Wright (seated), Mr. Michael Milne-Watson, Mme. and M. Jojkic, Mr. Edwin Bayliss.

Yugoslav people's chief sees North Thames Gas Board's methods

M. DJURICA JOJKIC, President of the People's Committee of Belgrade, and Mme. Jojkic, visiting London this month, toured the Fulham works of the North Thames Gas Board, where they were received by Mr. Michael Milne-Watson, Chairman of the Board, and Mr. Edwin Bayliss, Chairman of the Gas Consultative Council, Mr. J. A. Hepworth, Deputy Chief Engineer of the Board, and Mr. K. C. Mead, Station Engineer, Fulham. M. and Mme. Jojkic also visited Watson House, where they were introduced to Mr. L. W. Andrew, Director, and Mr. P. G. Wright, Administrative Secretary. The visitors also saw Imperial House, where Mr. R. N. Le Fevre, Training and Education Officer, showed them the Board's training centre.

Russia takes belting

Nearly six miles of rubber-covered conveyor belting designed and manufactured by BTR Industries Ltd., is now on its way to a large ore field in the Soviet Union. The contract was completed on schedule within three months. This vast Soviet conveyor installation is believed by BTR to be unique in demanding belting of exceptional width designed to standards never before attained—and in that it is the first application of 100% Terylene fabric in a major conveyor system.

LONG SERVICE AWARDS

Mr. D. C. Lorkin, Managing Director of the Lancashire Dynamo Group, presented 15 long service awards to employees of Dynamo & Motor Repairs Ltd.

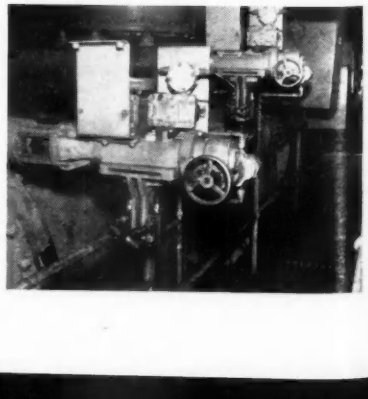
Southampton gasworks and the 'new look'

At the top of the page is shown the control room of the Humphreys & Glasgow Onia-Gegi plant, including the new instrument panel and, in the foreground, two automatic operators. **Above:** *The works foreman operating the pilot valve which actuates the inlet valve on the purifier plant.* **Right:** *the purifier valve equipped with hydraulic operating gear being controlled from the panel.*

RECENT developments have given very much of a 'new look' to Southampton gasworks, as has been reported from time to time. They are related to the supply of refinery gas from the Fawley Refinery of the Esso Petroleum Co., Ltd.

Our latest pictures show the controls of the new tray purifier installation and the control room and instrument panel of the two Onia-Gegi catalytic oil gas plants which can be used for reforming refinery gas into town gas or for making gas from heavy oil. Each plant will have a capacity of 4 mill. cu.ft. per day operating on heavy oil and 8 mill. cu.ft. per day on refinery gas.

One of the plants is now ready to be put into operation, and the other will be ready in the near future.



From a paper to the Eastern Junior Gas Association, Spalding, January 29.

Leakage Detection and the Work of a Survey Team

By E. R. FITCH,

ASSISTANT TO THE DIVISIONAL DISTRIBUTION ENGINEER,
LINCOLNSHIRE DIVISION, EAST MIDLANDS GAS BOARD.

THE object of this paper is twofold. First, to describe a modern instrument for the detection of gas leakages, working on the principle of the heat developed by the combustion of the inflammable portion of the sampled atmosphere as it passes over a heated catalytic filament, with the resultant unbalance of the electrical circuit of the instrument. Secondly, the paper describes the formation of a mains leakage survey team in the Lincolnshire Division and how the detector was successfully applied to the work carried out by it.

Methods of leakage detection. 1. Short's leakage indicator works on the principle of relative diffusion of gases according to Graham's law which states that gases diffuse into one another at a speed inversely proportional to the square roots of their specific gravities. That is to say, if the specific gravity of the gas is .5—air = 1—then gas will diffuse into air at approximately 1½ times the speed at which air will diffuse into gas. The Short's indicator consists of a cylinder with an open base above which is a porous tile. At the top of the cylinder is a flexible diaphragm connected to a pointer by a suitable linkage system.

Very Accurate

To trace a suspected leakage bar holes are made along the line of the main or service and the indicator is placed over the bar hole. Any gas present in the bar hole will diffuse through the porous tile into the cylinder, causing a build-up of pressure which will raise the diaphragm, thus causing the pointer to rotate around the dial, the dial being suitably marked out in percentages of gas present. This procedure is carried out over every bar hole until the maximum percentage is registered, at which point the necessary excavations are made. This instrument is very accurate but has one great disadvantage—the slowness of the instrument to register, particularly when the percentage of gas present is small. The instrument must be placed over the bar hole and left until diffusion has taken place and this can take some considerable time, especially if:

(a) The bar holes are not directly over the line of main.

(b) The bar holes are not down to the top of the main.

(c) The leakage is on the underside of the main.

This slowness of operation rules out this indicator as a suitable instrument for rapidly testing long lengths of main for possible leakages but nevertheless it is still a very useful instrument for day to day location of reported leakages. However a vastly different type of instrument is required if a rapid indication is to be given even with small percentages of gas present.

2. Mine safety appliances explosimeter—model 2—is an instrument for quickly and accurately testing the concentration of inflammable gases in an atmosphere. It depends for its operation upon the heat developed by the actual combustion of the inflammable portion of the sampled atmosphere. Tests are made by drawing a sample of the atmosphere to be tested over a heated catalytic filament which forms part of a balanced electrical circuit. The current for this circuit is provided by six standard No. U2 1½ V dry batteries. The combustibles in the sample are burned on the filament, so raising its temperature and increasing its resistance in proportion to the concentration of combustibles in the sample. The resulting unbalance of the electrical circuit causes a deflection of the pointer which indicates on the scale the concentration of combustible gases in the sample. The scale is graduated in percentages of the lower explosive limit, this being 5% in the case of a mixture of town gas in air.

The electrical bridge circuit of the instrument is designed so that its balance is established at the proper operating temperature of the detector filament. The circuit balance and detector current are adjusted simultaneously by the rotation of a single rheostat. The proper relation between these two factors is maintained by a special ballast lamp in the circuit.

The sample to be tested is drawn through the filter chamber into the combustion chamber by squeezing and releasing the aspirator bulb. Entering through the inlet flashback arrestor, the sample strikes a baffle plate, passes into the combustion chamber, flows across the detector filament and leaves through the outlet flashback arrestor.

Operation Routine

To test for combustible gases the explosimeter is operated as follows:

1. Lift the rheostat locking bar and turn the rheostat knob one quarter turn clockwise. This closes the battery circuit and due to unequal heating of the various circuit elements the pointer will move rapidly up the scale and then return to some point below zero.

2. Flush fresh air through the explosimeter. Five squeezes of the aspirator bulb are sufficient to flush the combustion chamber but if a sampling line is used an additional two squeezes will be required for each 10 ft. of line.

3. Adjust the rheostat knob until the meter pointer rests at zero.

4. Place the end of the sampling line into the bar hole.

5. Aspirate the sample through the explosimeter.

Normally six or seven squeezes of the aspirator bulb will be sufficient.

6. Note the reading of the pointer.

The gradings of the scale of the indicator are in percentages of the lower explosive limit and hence the deflection of the pointer between 0 and 100% shows how closely the atmosphere being tested approaches the minimum concentration required for an explosion. When the meter pointer is deflected to the extreme right of the scale and remains there, then the sample under test is explosive.

If the meter pointer moves rapidly across the scale and on continued aspiration quickly returns to a position within the scale range or below zero, it is an indication that the concentration of inflammable gases in the sample may be above the upper explosive limit. To verify this, immediately flush air through the sampling line. If the pointer moves first to the right and then to the left of the scale, it is an indication that the concentration of the sample is above the upper explosive limit, which is 31% in the case of a mixture of town gas in air. The indicator scale is coloured red from 60% to 100% to indicate that gas concentrations within that range are very nearly explosive.

Kept at Zero

The terminal voltage of the dry cells will gradually decrease throughout the day when the instrument is in constant use and the bridge circuit balance can be maintained by rotation of the rheostat. In this way the pointer can be kept at zero before each sample is tested for as long as required.

The six No. U2 dry batteries will give some eight hours of continuous service and thus when the instrument is in constant use throughout the day the cells must be changed approximately once every day. All cells must be replaced together and partly exhausted cells must not be mixed with new cells. The position of the rheostat knob indicates the condition of the cells and when the circuit is properly balanced with fresh cells the rheostat knob should be approximately one quarter of a turn clockwise from the 'off' position. With continual use, as the voltage of the cells decreases, the pointer is kept at zero by rotating the knob in a clockwise direction. When the rheostat knob has been rotated throughout its full range and the pointer cannot be brought above zero, then the cells are exhausted and must be replaced.

The detector filament is made of platinum and will normally last for several thousand tests. Obviously the life of the filament will be shortened when high concentrations are regularly encountered. A spare filament is located inside the instrument and can be speedily fitted in place of a burned out filament.

The function of the ballast lamp is to regulate the circuit stability; this lamp is specially manufactured for the instrument and cannot be replaced by any other commercial lamp. Unless the ballast lamp is subjected to severe mechanical shock such as the explosimeter being dropped, it can normally be expected to last throughout the life of the instrument.

The function of the flashback arrestors is to prevent the possibility of flame propagation from the combustion chamber. They consist of a cadmium plated copper screen tightly wrapped upon a rod. As the samples drawn through the instrument invariably contain a certain amount of dust, etc., from the bar holes the flashback arrestors gradually become clogged and must be replaced. The arrestors are inexpensive and in view of the importance of their function any attempt to clean them is not recommended. When replacements are not available, washing the arrestors in water may render them serviceable but they must be thoroughly dry before being replaced. Inflammable solvents must never be used for this purpose.

The normal rate of flow through the explosimeter is .025 to .045 cu.ft. per minute. As the sample will invariably contain dust a cotton filter is inserted before the inlet flashback arrestor to prevent this dust being drawn into the instrument. These cotton filters must be replaced as they become clogged or damp, which will be indicated by a reduction in the speed of the response of the instrument or by a decrease in the rate of operation of the aspirator bulb.

The rate of flow through the instrument is controlled by an orifice in the aspirator bulb coupling. It can be screwed out after the rubber tube connection of the bulb is removed and if it is clogged it can be cleaned with a fine wire.

When testing samples drawn from bar holes, should there be any doubt as to whether the reading obtained is from the combustion of towns gas or from the combustion of petroleum vapours, an activated charcoal filter can be inserted in place of the cotton filter. This charcoal filter will absorb petroleum vapours and no reading will appear on the dial. Unfortunately, the present instrument cannot differentiate between towns gas and sewer gas but I understand that experiments are being carried out and this may be possible in the near future.

'Off Scale'

When testing a series of bar holes where concentrations of gas in excess of the lower explosive limit are being encountered, that is to say concentrations of over 5%, it will be appreciated that as 100% on the instrument dial is equal to 5% concentration in the sample, the readings will all be 'off scale.' Obviously the position of the leakage cannot be determined with the instrument as it stands. However, to overcome this difficulty two dilution tubes are available. These tubes are made in the ratio of 10:1 and 20:1 of air to the sample, thus enabling rich concentrations to be compared until the highest reading is obtained. The dilution tube is connected by screw threads between the intake of the explosimeter and the end of the sampling line which is normally attached directly to the explosimeter. The side of the dilution tube is drilled so that as the aspirator bulb is released air is drawn in through the drilling to dilute the sample being drawn up the sampling tube. Obviously the 20:1 tube has the larger drilling. These dilution tubes can also be used as a quick guide to sample the mixture in a main being purged from air to gas to enable an approximate idea to be obtained of the concentration of gas in the main.

Operational use of the explosimeter. How can we make the most effective use of this sensitive instrument? The purchase price of this instrument complete with batteries, spare filters, etc., is approximately £35, while

the price of the Short's leakage indicator is less than £10. The cost may appear prohibitive for smaller groups where the number of leaks is small. But the intelligent use of the instrument enables the location of a leak to be pinpointed far more accurately than has ever been possible before. By saving unnecessary labour in excavation and expense in reinstatement, this instrument can soon repay the capital outlay necessary for its purchase. In fact this instrument will probably become the standard leakage indicator for the gas industry.

Notorious Subsidence

Can this instrument be used to check the condition of distribution systems? The need for some reasonably quick method of testing mains and services has long been apparent but can this be done? The East Midlands Gas Board took the view not only that this can be done but they felt most strongly that it must be done. Accordingly a team of Dutch experts was called in and an area notorious for its subsidence was used to test out the method. This Dutch team used an instrument very similar to the M.S.A. explosimeter Model 2 and by drilling holes every 6 ft. along all the mains in the area selected and testing the air in these holes with the instrument, the area concerned was quickly surveyed.

The results of this survey were quickly realised to be of tremendous value to the Board. Here it was felt was a method by which up to two miles of main per day could be tested without any excavation or cutting off at all. Equally important, leaks, large or small, which had not yet become apparent to the general public could be pinpointed and repaired. This operation was, however, expensive, costing at that time about £22 10s. per mile surveyed. The present-day cost of this survey is about £27 10s. per mile but this can be reduced as low as approximately £18 per mile if the team is continually employed in the same area for two years or more. It does not include any reinstatement of the holes drilled for the survey, which increases the cost by some £2 per mile. The East Midlands Gas Board was satisfied with the results of the trial and decided that the cost could be reduced by doing the survey by direct labour and plans were put into operation for the formation of leakage survey teams throughout the whole of the Board's area.

There is no simple solution to the problem of defining the exact composition of a survey team, either in terms of personnel or equipment, but the most efficient way of organising the team must take into account the following factors:

a. The length of mains in the Division to be surveyed.

b. The time in which it is desired to complete the survey.

c. Utilisation of transport.

d. The strain which the activities of the team would put upon the local mains gangs in effecting the necessary repairs.

e. The nature of the area to be surveyed, *i.e.*, town, city or rural area.

f. Underground conditions, *e.g.*, subsidence.

The first essential in the formation of the team is, as in any other team, to find a good leader. He must have a background of gas industry training, experience and knowledge, be keen and of above average intelligence. The team leader chosen was designated mains inspector and a decision was taken to base the team and its equipment at the undertaking from which the mains inspector had been drawn, *i.e.*, Market Rasen. This small market town is geographically in the centre of the Division, within easy reach of Divisional Headquarters and has ample garage and storage space available to accommodate all the equipment.

An existing 10 cwt. Fordson van was modified and licensed for towing and a new portable Broomwade SV 78 diesel compressor capable of delivering 60 cu.ft. of free air per minute at 100 p.s.i. was purchased together with a B.W.D. 230 hand hammer rock drill fitted with crossbar handle and $3\frac{1}{4}$ in. by $\frac{7}{8}$ in. hexagon chuck. After a valuable period of observation and discussion with a survey team of some months experience operating in the Nottingham area, the team leader and myself, together with a driver, began a series of operational experiments to determine the future strength of a team suitable to our own conditions.

During the first three weeks the leader was becoming familiar with the instrument and the driver gained experience with the compressor and the rock drill. This drill had a nett weight of 29 lb. and was therefore much lighter than the customary road breaker. It must be emphasised at this point that it is essential to use a drill and not a road breaker, since the road breaker not only does quite a lot of damage to the roadway, but is also much slower in making a hole. It defeats the object by pounding the earth solid at the bottom of the hole and helps to delay the diffusion of any gas present in the hole. A drill with a crossbar handle is essential so that the operator can use both hands to steady the drill. Since each operator can drill up to some 850 holes per day, steps must be taken to make his job as easy as possible.

Minimum Movement

During this period efforts were made to speed up the drilling operations by using two 60-ft. lengths of hose attached to the drill so that the movement of the van and compressor could be kept to a minimum. The driver would be able to drill in between times of moving his vehicle, which would only need to be moved every 80 yards or so. It was soon found, however, that the effort of pulling the drill attached to 120 ft. of hose was not only fatiguing to the operator but was something of a menace to local traffic. It was therefore decided to engage another man to operate a second drill. Each drill then had 60 ft. of hose attached to it but the driver still had to continually break off from drilling to move the van and compressor forward. Since each of the rock drills requires some 50 cu.ft. per minute of free air at 80 p.s.i. and the compressor delivers 60 cu.ft. per minute of free air at 100 p.s.i., two drills cannot be used at the same time which meant that the driver was continually breaking off either to move the equipment or to let the other driller operate. Using two drills, each with an operator drilling alternate holes, seems to be the only way by which continuous drilling can be carried out since it is physically impossible for one operator to work non-stop throughout the working day.

During the early days we were continually experiment-

ing to find the most suitable drilling stem and tests were carried out with several different types. In the past the division had used a type with a screwed base, the end of which could be removed as the cutting points wore down and replaced with a new tip. Various types of tips were used, all of which drilled quite rapidly, but they all had one fault in common—either the tip of the drill was left in the hole or the tip remained on the stem which could not be withdrawn from the hole. It was going to be rather expensive to use one tip per hole or to be faced regularly with the prospect of a second drill having to be used to get the first drill out of the roadway. Finally a type of drill stem which was far superior to anything we had used previously was tried and has been in continual use ever since. This is the Riploy tungsten carbide tipped drill stem with a single chisel bit, available in varying diameters and lengths below the collar. Since the stem is only required to penetrate through the crust of the road or footpath, the length of the stem can be kept to a length suitable for this, while having the added advantage of preventing the drill from penetrating too far and avoiding the risk of damage to other public utilities' apparatus. It also makes drilling easier for the operator, an important point when drilling so many holes.

Reduced Speed

The smaller diameter stems were proved satisfactory when used on asphalte or stone flagged footpaths. When used on the carriageway, however, their speed of rotation was much reduced by the tar melted from the tarmac by the heat generated by the high speed rotation of the drill stems. The stems had difficulty in keeping themselves clear, which obviously affected their speed of rotation and therefore their speed of penetration. Conversely, the larger diameter stems were somewhat rough on stone flags and after long trials it was decided to use $\frac{3}{4}$ in. diameter stems, 18 in. long below the collar, for all work in the footpath and 1 in. or $1\frac{1}{4}$ in. stems, 20 in. long below the collar, for all work in the carriageway. It was also decided that the quickest method of operation either in the grass verge or through agricultural land was to use a pricker bar and hammer.

After a few weeks it was realised that even with the experience gained, the team would not be able to achieve the survey of the whole division in five years. There are some 1,200 miles of main in the Lincolnshire Division and on a basis of five working days per week for 40 weeks per annum, which takes into account holidays, sickness, inclement weather, etc., it was necessary to maintain an average of 1.2 miles per day.

It was decided, therefore, to employ a further drill operator so that the driver could remain at the wheel of the van to move the equipment along at a snail's pace. There was an immediate and gratifying increase in the number of yards surveyed per day and after a week or two we began to reach the target of over a mile per day. These lengths were all in villages, large and small, and most of the mains surveyed were in the carriageway. The team had now been finalised and consisted of the leader, designated the mains inspector, the driver, who was responsible for the van and compressor and two drill operators. The latter were drilling alternatively, that is to say, one would be drilling a hole while the other moved up 6 ft. past him. Immediately the first operator had finished drilling, he shut off the air and the second operator began to drill. The first operator moved 6 ft. past him and so they progressed leapfrogging in this way.

The next improvement was to reduce the length of hose on each drill to 30 ft. which meant less fatigue for the operators and which proved a great advantage in heavy traffic conditions since it kept the whole of the team as compact as possible. By using this method and with the improved technique of the drillers, the daily average rose until a record day of 3,437 yards was reached, all in the carriageway. The drillers had discovered by now that it was less fatiguing to themselves to cup the crossbar handle of the drill in their palms rather than to grasp the handle as if one were riding a motor cycle, the former grip proving much less fatiguing for a full day's drilling. Experience now shows that when surveying mains laid in grass verges or in arable land it is not unusual for the team to reach up to seven or eight miles per day.

Having reached the point where it was possible to drill up to a maximum of 1,700 holes in a day one problem still remained—how to effectively reinstate those 1,700 holes in a day. It may sound rather odd at first but the problem of satisfactorily filling the holes, and at a reasonable cost, was proving to be of greater difficulty than the drilling of so many holes. The question of filling up all these little holes was the cause of some concern to the local surveyors, as it was to us. Their main concern was to see that the holes were filled in and the top properly sealed to prevent the rain getting through the crust of the roads and undermining the foundations. Not only is the large number of holes drilled a problem but equally so is their small diameter since it is clearly much easier to seal up the top of a large hole than the top of one $\frac{3}{4}$ in, 1 in, or $1\frac{1}{4}$ in. in diameter. One or two of the surveyors insisted upon various sandwiches, such as gravel topped by sand and sealed off with tarmac. After one or two efforts to meet their wishes I had to plead for something a little less involved since the prodding of all these items into a hole of such small diameter and some 12 in. in depth was something that required considerable skill and patience as well as being horribly expensive.

The Solution

After many unsuccessful attempts, the solution came from a representative of a quarry in the Peak District of Derbyshire who had heard that we were conducting this leakage survey. He suggested that a by-product of theirs called $\frac{1}{16}$ in. down broken dried limestone might be suitable for filling up these never ending holes and he travelled with me to Scunthorpe to fill up a few of the holes to show just how easily it could be done. Using a small can containing this dried limestone, which was so dry that it could be poured out of the can as easily as water, he poured it into the hole, prodded it down a little, topped it up and then poured on a bitumen solution which effectively sealed the hole with little fuss or bother. What he had done in actual fact was to make cold asphalte on the spot. The team returned to the spot the following day and tried to open up the same holes with a bar and a hammer but found that it

was necessary to drill them out again. An order was immediately placed on receipt of a quotation offering limestone of this type at 54s. 3d. per ton in six ton lots delivered and a 40-gal. drum of bitumen solution at a cost of 1s. 11d. per gal., delivered within three days. This speedy delivery has been maintained. The limestone of course must be kept perfectly dry so that it can be poured from the can. Because of its fine texture it beds down very solidly into the hole and after a jab or two with a rod it goes down no more than an eighth of an inch. After topping up and sealing with the bitumen no settlement ever takes place.

Average Cost

One man can keep up with the team, and fill in all the holes drilled during the day. The average cost of reinstating these holes is about £2 per day or just under £2 a mile, including labour and materials. Approximately 1½ cwt. of the limestone are needed per mile at a cost of 4s. 1d., and since the cost of the solution per mile is negligible, the major portion of the cost is the labour involved. Since this method of reinstating the holes was adopted, there has not been one complaint. The survey of Scunthorpe has recently been completed, 125 miles of main have been surveyed and the Borough Surveyor has expressed his complete satisfaction with the reinstatement. There is, however, one little hint which should be observed and that is, after pouring on the solution, a little dry limestone on the top will prevent the tacky solution from sticking to people's shoes or being pulled out by passing vehicles.

An incident occurred during the survey of Scunthorpe when a newish housing estate was being surveyed and the explosimeter gave readings at almost every hole. After some six or seven holes had been dug out and no trace of any leakage found, not only was the faith of the repair gang in the instrument somewhat reduced but also tempers between the survey team and the repair gang were getting somewhat frayed. The explosimeters were checked and found to be in perfect working order and I visited the site to inspect the local conditions. A sampling hole was made in the middle of the field which was being prepared for future development and which had at the moment no mains or services within 100 yards. The explosimeter probe was inserted into this hole, a sample was drawn through the instrument, and the needle went straight off the clock. After looking at the soil where a previous excavation had been made I had the hole dug out in the middle of the field where the last reading had been taken and there about 12 in. below the surface was the answer—a thick pad of peat. The marsh gas or methane given off by the peat had collected in pockets and the concentration of the gas in these pockets was fairly strong. Methane with a c.v. of 995 B.t.u. per cu.ft. passing over the filament of the explosimeter even in small amounts causes a violent increase in the temperature of the filament. Fortunately methane diffuses rapidly into the atmosphere and once the pockets were vented by the drill the gas quickly dispersed and a few seconds later no reading could be obtained on the instrument.

The question which must repeatedly spring to mind is—what effect can this survey have upon our unaccounted-for gas figures? Clearly there can be no drastic savings since the percentage of unaccounted-for gas due to leaks in mains and services is only estimated to be between 1% and 1.5% and, therefore, one can only look for a small percentage reduction. To estimate how much gas the survey might save, a 400-cu.ft. per hour meter was connected across the outlet valve of the town governor at two villages where it was certain that the late night load would not exceed the capacity of the meter. The governor outlet valve was closed so that any gas passing out to the district must pass through the meter. The meter was installed immediately before the survey began and again immediately after the survey had been concluded and all repairs completed. In each case the meter was read for three nights in succession (on each occasion on the same nights of the week) between midnight and 1 a.m. Though it will be appreciated that someone putting on a kettle at this late hour could upset the figures, results obtained showed that the amount of gas passing out to the district after the survey was completed was reduced by some 2 cu.ft. an hour for every escape repaired. This may seem a small saving, but at our present rate of progress we shall repair some 420 leaks during our first 12 months. These repairs represent a first interim annual saving of 36,700 therms, or a cumulative annual saving of 183,500 therms after the completion of the divisional survey at the end of five years. This cumulative total represents .76% of the total divisional sales and at 10.313d. per therm is the equivalent of £7,900. These savings, however, are not strictly accurate as it has been assumed that the leakages found and repaired by the survey would not have been revealed in the normal course of events.

Faint Smell

The explosimeter can also be used to detect gas leaks in the works as the following example shows. The compressor house at Bracebridge works, Lincoln, is a new, lofty, airy, well ventilated building. In spite of the fine ventilation of this building there was always a very faint smell of gas though the whole of the mains and equipment inside the house had been tested. Minor repairs had been carried out, but this faint smell persisted. All the pipework in the compressor house is exposed, and is either above or below the usual type of open mesh flooring. The Short's indicator is of little value on exposed pipework and at the request of the Divisional Distribution Engineer all the valves, joints, etc., in the compressor house both above and below the flooring were tested with the explosimeter. A total of 14 small leaks was found. So accurately could the leaks be pinpointed that with leak No. 14, a 3 in. flanged joint, a chalk mark could be put at the exact spot from which the leaking gas was coming, although no indication was given with the usual soap and water test. The necessary repairs were carried out and re-checked with the explosimeter. It is interesting to note that before the tests were started a test of the atmosphere in the house gave a reading of .25% of gas, while, when re-tested after the repairs were completed, there was no movement at all of the explosimeter needle. Following this test, it is now the established practice that all compressor houses in the division are tested every six months.

An analysis of costs of the survey is given in an appendix to the paper. In it the undertakings have

been listed in the order in which they were surveyed, with the exception of that part of the North Lincolnshire grid, which has been kept separate in view of the large percentage of verge in the total length surveyed. The word 'verge' does not necessarily mean that the mains surveyed in the lengths shown under this heading were always actually laid under the verge. It means in fact that the holes for the survey were made in the verge but the main could be out in the carriageway or in the footpath. Thanks to the sensitivity of the explosimeter it was possible to test the main by making holes in the verge, which is of course much less expensive and can be done much faster. In fact the word 'verge' has been used to indicate any part of the survey where it was possible to test the mains without the use of the compressor and drills.

The cost per mile at the first undertaking surveyed, *i.e.*, Market Rasen, worked out at £27 5s. 4d. per mile, which is very expensive. However, this cost was steadily reduced as the team became larger and the technique of the team improved. When the surveys of villages equivalent in size to Market Rasen were completed a few months later, *i.e.*, Kirkton Lindsey, Barrow-upon-Humber and Winterton, the costs per mile had been reduced to £10 11s. 4d., £9 4s. 3d., and £7 1s. 7d. respectively. This shows that as the number of men in the team was increased to four a reduction in the cost per mile was achieved and I am convinced that the present team is the most efficient possible.

Another important factor in the cost per mile is the distance travelled by the team to the area being surveyed. This division, which to all intents and purposes follows the county boundary, is probably the largest in the country, when considered purely from a standpoint of length and breadth. Most of the undertakings in the division involve a journey of at least 50 miles per day for the team, with a resultant decrease in the number of hours worked on the actual survey. When undertakings are as far away as Spalding, Stamford, etc., over 40 miles from Market Rasen, we have decided that in future the team will be billeted out in that area during the period Monday night to Thursday night inclusive. Based on the costs given in the appendix for Spalding, a reduction in cost of some £2 per mile would be made possible by this method. In Spalding, where the team worked for some two hours overtime each night, it was proved that costs could be reduced by employing the team on overtime where the distances to be travelled each day are excessive.

Number of Leakages

Another factor which has a direct influence on the cost is the number of leakages revealed by the survey at each undertaking. The Lincolnshire team drills along, or parallel to, the line of main and when readings are obtained the team carries on along this line until the maximum reading is found. The team then drills holes from this point at right angles to their previous line to determine whether the leak is on the main itself or on a service running off the main. In this way the exact position of the leak can be pinpointed very accurately and the position is marked by a ring of paint. This procedure makes the job of the repair gang much easier but it does tend to slow up the survey team if a large number of leaks are found. This system of leak location is not followed by some other divisions or boards, where the survey team carries on along the line of main until the highest reading is obtained. This spot is marked but the exact pinpointing is left to the repair gang. I cannot help but feel that it is preferable to place the onus for the location of the leak with the survey gang rather than with the repair gang. As the survey team enters a new group an explosimeter is purchased for use in that group and members of the local distribution personnel are trained in its use. By the time the survey has been completed and the survey team has left for other fields, the group is left with trained personnel who will be competent to use the instrument to locate any further escapes as they are reported.

The intention of this paper was to prove that not only is a detailed survey of our distribution systems technically possible but that it is also economically worthwhile. Financial considerations apart, can we morally afford not to carry out such a survey now that the necessary equipment is in our hands? Obviously we are bound to do all we can to reduce the number of incidents caused by escaping gas. Since the total cost per annum of a survey team is £3,144 and the estimated number of therms saved per annum by the team is 36,700 at a cost of £1.580, it follows that after two years the team itself is self-supporting. From then onwards the amount of money saved rapidly outstrips the cost of the team. Not only is a good service given to the public but we are also more than saving the costs of the survey.

DISCUSSION

Mr. Bernard Clarke, Divisional General Manager, Lincolnshire Division, E.M.G.B., opening the discussion, said that it was a fact that the E.M.G.B. had dealt with the problem of leakage a few years ago, and that they were checking all the time, so that they gave the public assurance that their distribution system was in a first-class conditon. In his paper, the author had been practical and had shown that techniques had been improved. Over and above that they had subjected this method to work study investigation, and from this concluded that they could operate in different ways to reduce costs still more. 'We have,' he said, 'a real responsibility to the public and we should assure them that everything is being done about the leakage problem. Now that big advances had been made in this connection, the public had a greater sense of security.'

Mr. J. W. Wilson, Distribution Engineer, Lincolnshire Division, E.M.G.B.: The Eastern Gas Board was the first Board to employ contractors in a planned survey of mains and services from the leakage point of view, and in the very early days of their work I visited Harwich as an observer and gained several immediate impressions. On the credit side this appeared to be a first-rate system of examining underground apparatus for leakage; secondly, even very small previously unreported leakages were being indicated. Thirdly, a distribution system would obviously be safer after being surveyed and followed up by repair teams, and finally, the results must make a physical and positive contribu-

tion to a reduction of unaccounted-for gas, which might conceivably finance the work involved.

On the debit side however, the cost of the survey at approximately £22 per mile exclusive of reinstatement, supervision and overheads, was very high. Secondly, some of the small leakages being revealed by the sensitive J.W. explosimeter were not even 'on the clock' of the less sensitive traditional indicator used by the repair gangs and because of this, large excavations and subsequent reinstatement, costs were frightening. Finally, as a result of the very large excavations, venting of the suspected leakage area was inevitably reducing even further the chance of easy location of pinhole leaks.

Our own activities in this field commenced at this point and after an unsuccessful attempt by direct labour to marry the speed of the continuous drilling technique to the simultaneous use of several traditional leakage indicators, the trials and the errors outlined in Mr. Fitch's paper were embarked upon.

Although we now feel that our survey team is a highly efficient combination of men, machinery and materials and has overcome most of the original debit side problems, we are still looking for improvement in all its phases.

It is quite certain that this type of work can be carried out less expensively by direct labour than by contractors but whichever method is employed depends upon so many factors, such as the type and size of area to be surveyed, priority areas, the type of ground conditions to be expected, presence or not of subsidence, the age and condition of the underground apparatus, the speed at which it is considered the survey should be completed and the frequency at which future surveys are to be carried out.

Sense of Responsibility

'Adverse publicity,' he went on, 'arises from time to time as a result of such leakages which unfortunately result in fatalities. Broken or cracked mains attract headlines but we are members of an industry with a strong sense of responsibility and we know that any leakage of town gas from whatever source and however small, is the immediate dangerous origin of a potential incident, which must receive our immediate attention, however trivial the eventual outcome may turn out to be. Operating a leakage survey is a technique which can be very rewarding in the hands of experienced operators but it must not be considered to be infallible and we must always be prepared to face the position of a cracked main or leakage of some description occurring immediately after a survey has indicated negative results.'

Mr. R. W. Hilham, District Manager, Colchester District, Ipswich Division, E.G.B.: The town of Harwich was the 'guinea-pig' for this type of survey and I was fortunate in being responsible for the reception of the Dutch team when they first operated in this country. The procedure of operation was as described by Mr. Fitch and 21.218 miles of main were tested in this way. Work commenced on August 16 and ended on September 11; a five-day week being operated and no work was carried out during inclement weather. The Dutch firm provided a daily report giving details of the number and position of holes drilled which included one every 6 ft. over the main and one over each known service position. They reported on each drilling as: (1) sound, (2) minor leakage, (3) medium leakage, (4) major leakage, according to the readings shown by their J. W. explosimeter. In all, 114 leakages were reported and since this operation was in the nature of an experiment an immediate follow-up was necessary. Six gangs of two men were therefore drafted into Harwich and checks on the test teams reports were made immediately.

A summary of the reported leakages were made as follows:

As mains leakages	...	87	Total 114
As service leakages	...	27	
As minor leakages	...	10	Total 114
As medium leakages	...	24	
As major leakages	...	80	

It was very quickly found that adjacent 'leakage' reports could be inter-related and after some experience with the explosimeter the actual 'leakage' to be opened for examination was readily decided upon, which of course reduced the number of openings and repairs. from the 114 leakages reported, 90 were found and repaired and only in three cases were we not successful in confirming the test drilling.

Less Road Opening

'Perhaps I may be allowed,' he went on, 'to confirm Mr. Fitch's statement that by this method of detection a considerable saving in road openings was possible; after we had become accustomed to the machine, the escape was nearly always found within an excavation 3 ft. by 3 ft., the maximum distance from the point of record being 10 ft.'

In the early stages of the experiment, the Dutch team's findings were disputed and they were called upon to confirm their tests. In all cases, they did so and a leakage was ultimately found. It is of interest to note that in the case of leaking joints, the application of soap and water after excavation failed to locate the leakage due to earth deposits embedded in the irregularities of the lead joint. After brushing and thoroughly cleaning the joint, the leakage was discovered.

He continued, 'This test was not made so much with the view to obtaining "costs per mile" as to prove the effectiveness of the method. Being experimental, much time was lost in unnecessary excavations made to prove the teams report. It is therefore not fair to compare our costs per mile. There is however no doubt as to the efficiency of the method and this is proved to some extent by the fact that a most excessive "unaccounted for" at Harwich amounting in 1956/1957 to 13.56% was reduced in 1957/8 to 10.77%. I would like to ask Mr. Fitch two questions: (a) Was the "filler of holes" additional to the team mentioned on [p. 13] and did he follow up immediately or was this work done by the whole team at a later date (b) How were the escapes finally located and repaired as a quick follow-up as in our case or as a separate operation at a later date. This matter was my major concern and headache, although I appreciate that in the Harwich case, being a No. 1 experiment, it was vital to prove the effectiveness of the survey while the team was still in the district.'

Mr. J. D. Burgess, Lincoln: Earlier this week I carried out a second survey of the Lincoln compressor house,

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Eastern Junior Gas Association

PLASTIC TUBING IN THE GAS INDUSTRY

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THE author was prompted to submit this paper following the installation of a 4-in. polythene gas main by engineers of a local chemical works. Technical information as to the suitability of this material for use with town gas was not considered conclusive, and an unconfirmed American report in their hands was not sufficient to deter them from the project. A previous mild steel pipe installation had been subjected externally to the corrosive atmosphere within the works and had had a life of approximately five to six years. This steel pipe was constantly subject to stoppage due to internal corrosion and required annual breakdown for clearing obstructions. Information is given later in this paper on the uptodate use of plastic tubing as applied to the gas industry, but in the meanwhile it may be of interest to state the manner of installation of the polythene main.

Easily Handled

The plastic pipe has been fixed on the exterior of the works buildings, and from the meter house spans a roadway on a 40-ft. lattice girder, approximately 20 ft. above ground. On the girder the tubing is supported throughout its entire length in half round 20 gauge aluminium guttering which rests in timber bolsters at 4-ft. pitch. The remainder of the supply is fixed to the external face of the buildings on suitable brackets at 5-ft. intervals and the polythene supported again in the guttering on wood bolsters. Jointing was completed either by socket or sleeve welds. Due to the lightness of the material lengths of 20 ft. to 30 ft. were easily handled. The coefficient of expansion of polythene is approximately 15 times that of steel necessitating expansion loops at regular intervals. Flanged joints are completed with $\frac{1}{8}$-in. soft rubber gaskets, and joints are welded with a gas or electrically heated welding torch. Nitrogen is used at about 2 p.s.i., and the temperature of the gas leaving the torch should be in the order of 300°C. The welding rod should always be of the same grade as the pipe, and the contacting edges should be bevelled to give an included angle of 60° and the edges clean and free of oil. Some fittings are manufactured with an integral heating element and the jointing completed by the application of an electrical current. Where heavy gauge polythene tube is used B.S.P. taper threads can be cut by hand. All types of B.S.P. sockets and unions can be used.

A sample of the tubing was removed after 12 months and was found to be in satisfactory order both externally and internally. The only peculiarity has been the elongation of a section of the pipe in cold weather, attributed to an unrelieved stress in the pipe following extrusion. I would now like to turn to the question of the permeability of plastic tubing to town gas. Much research has been done and continues to be carried out in this connection by the Water Research Association. Specific cases have occurred under service conditions where gas having leaked from a fractured pipe, saturated the soil and within a few days consumers reported smell or taste of gas in the water supply. In all cases the polythene pipe was laid adjacent to the gas pipe. Contamination occurred, clearly defined, in the water supply following the repair of a gas escape found when the polythene supply was installed. Further evidence of contamination has been produced following the use by a consumer of gas liquor as a weed killer. The earth surrounding a polythene water service pipe was saturated with the liquor and the water supply tainted. It is believed that the permeability of polythene by town gas does not follow Graham's Law, but that the process is of solution of compatible substances through the amorphous parts of the polythene. It is thought that the small percentage of aromatic compounds in town gas produces this contamination.

Field Experiment

A field experiment to obtain practical knowledge of contamination of water in polythene pipe by town gas was started and continues. Three parallel trenches were dug in the clay soil. A gas supply was laid in the centre trench and a leak made in the pipe half way along the trench. Five $\frac{1}{2}$-in. water services were laid in the trench, in two gauges of polythene and one thickness each of rigid P.V.C., styrene-butadiene and nylon. In one parallel trench 2 ft. from the centre one, a normal gauge polythene service was laid and another polythene and a lead service laid in a trench 4 ft. from the centre one. The eight services terminated in a sampling pit. The trenches were cut and backfilled in October, 1956, and at the end of January, 1957, the gas leak was started at the rate of about $4\frac{1}{2}$ cu.ft. per hour. One month after starting the leak, the smell of gas was detected in the water, which was changed daily, in the normal gauge polythene, and three months

This is the first of three papers submitted in the short paper competition of the Association in December 1958.

after the start the gas contaminated the heavy gauge polythene. By June, 1957, no other pipe had been contaminated internally except the two gauges of polythene in the centre trench. Work is being carried out to formulate a code of practice for the laying of water supplies in relation to gas pipes from practical experience of water undertakings.

In the gas industry research has been carried out on plastic pipes such as P.V.C. and cellulose acetate. An investigation of a plastic tubing with reference to its use for gas services was carried out. The tubing was of the P.V.C. type approximately 1.35 in. in diameter with a wall thickness of $\frac{1}{8}$ in. was capable of carrying a surprisingly heavy mechanical load. The plastic tube was impervious to gas and unaffected by prolonged immersion in petroleum or hydrocarbons such as kerosene and gas oil, but was noticeably affected when immersed in the liquid benzole recovered from coal gas; it softened and became very pliable, deformed on crushing which remained permanent, and did not regain its original rigidity. These conditions were more drastic than would occur in normal distribution, so the behaviour of the plastic was examined in atmospheres containing benzole vapour. Coal gas stripped of benzole, was without noticeable effect after some weeks of exposure, but when saturated with benzole vapour produced a slight but measurable loss of rigidity. P.V.C., therefore, is virtually inert towards gas which has been treated for benzole recovery. Where this is not the case slight absorption of benzole might occur, but it is considered that changes produced by gases of normal benzole content (about one fifth saturation value) would be unlikely to lead to failure of the pipe.

Absence of Attack

It was concluded that a minor consequence of the solubility of benzole in the plastic might odorise the surrounding soil giving rise to complaints of gas leakage. However, the subsequent experimental laying of gas services shows no evidence of this. The long term durability of P.V.C. tests have shown it to be one of the most inert of plastics to those influences which cause slow decay of such materials, *i.e.*, light, air, moderate heat, and chemical agents. At the time (1953) P.V.C. appeared the most promising plastic tubing available for experiments. Service pipes have been laid in the Kent Suburban Division and latterly in the East Surrey Division of the South Eastern Gas Board. The first three of these were of cellulose acetate; the last eighteen pipes were of rigid P.V.C. These are part service pipes, plastic tubing being used from the main to within a few feet of the premises to be supplied. Jointing at the main was carried out by means of a service tee with a rubber ring compression joint onto the plastic tubing. Samples of tubing which have been exhumed after one year show the absence of attack. The cellulose acetate tubing was found to soften after use and was found to be liable to deformation by stones, etc. Both the thin wall P.V.C. and cellulose acetate were jointed by forming a socket in the following manner. The tube is heated in boiling water and pushed into a mandrill which must be rather larger than the spigot to allow for a shrinkage when the tube cools. Cellulose acetate can be welded by using an acetate solvent. P.V.C. is usually cemented by a suitable adhesive. The further sample which has a nominal bore of 1.143 in. is now favoured and with the aid of compression joints and plastic sleeves for joining lengths, installation is simple. At a point some 6 ft. from the building line suitably wrapped steel pipe is taken to the meter position.

In order to simplify stocks, the plastic pipes are ordered to have the same outside dimensions as steel pipe. The gas flow through a plastic pipe of 1-in nominal bore is equivalent to a $1\frac{1}{4}$-in. nominal bore steel pipe with the same pressure drop. On a price basis 1 in. plastic tube compares favourably with $1\frac{1}{4}$ in. internally painted and externally wrapped $1\frac{1}{4}$ in. pipe. In the heavy clay soil in this particular area of South Eastern Gas Board steel service pipes with internal and external protection have corroded severely in approximately two years. Some plastic services have been in use for four years without deterioration, and P.V.C. tubing laid at 2-ft. cover is not likely to be affected by traffic load. It is essential that the rigid P.V.C. tubing is laid on a firm bed, and the use of a thrust boring machine will ensure satisfactory installation. It is envisaged that service pipes of this material will last the life of the house to which it is installed, and that time expended on clearing and relaying services may be eliminated.

As an example of permeability of plastic tubing to town gas, a pipe of 1.075 in. o.d. with wall thickness of .10 in. was found to have a permeability in 24 hours of 2.8 cu. in., which is equivalent to a value below 1 cu.ft. per annum for a 10-ft. length of pipe of this dimension. Figures are available from tests on P.V.C., polythene and cellulose acetate butyrate pipes which indicate that their permeability does not make plastic pipes any less suitable than metal tubes. Plastic sheathed tubing is available for services in aggressive soils. Rigid P.V.C. and flexible polythene tubing is being used for internal gas supplies where steel pipes have previously been attacked by corrosive liquids.

With the experience gained in varying degrees in the U.S.A., Holland and other countries, it does seem that the use of plastic tubing will grow. Engineers in this country who are pursuing this matter are to be congratulated for opening up this field which may ultimately be a further factor in stabilising the prices of town gas.

N.S.C.A. Annual Conference

THE complete report of the 1958 conference of the National Society for Clean Air is an addition to the literature on air pollution and the means for its prevention. In addition to the sessional papers and discussions it contains an address by the Minister of Housing and Local Government, the Des Voeux Memorial Lecture by Sir William Holford on 'Clean Air, Urban Amenity and the Growth of Towns,' and a Presidential Address by Dr. R. Lessing.

For those concerned with either the technical aspects of implementing the Clean Air Act, or with the problems of its administration, the sessions on the industrial aspects of the Act, and on smoke control areas, will also be found to be valuable for the information they contain and the points of view they reveal.

From a paper to the Yorkshire Junior Gas Association

Types of Lubricating Oil; Its Choice and Testing

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THE purpose of this paper is to show the relationship between the tests carried out in the laboratory and the results obtained at the points of application for specific lubricants. It is not, however, possible to deal with all the tests for all the grades with which you come into contact. The grades have been selected to cover the major requirements of a normal gas undertaking, and I have selected the tests which can most readily be related to the specific uses. The types of oils to be dealt with are as follows:—

1. Engine and machinery oils.
2. Steam cylinder oils.
3. Crank chamber and gas cylinder oils.
4. Turbine oils.
5. Gear oils and compounds.
6. Hydraulic oils.
7. Rope compounds.
8. Exhauster oils.
9. Transformer oils.
10. Lubricating greases.

You will notice that internal combustion oils for petrol and diesel engines have not been included, since this range of oils, even if taken alone, would require much more time than is available. Actual proprietary grade names will not be referred to nor will any particular grade be described which is manufactured to meet the specifications of the Gas Council.

Four Tests

All lubricants are normally tested to determine (1) the corrosive sulphur, (2) the specific gravity, (3) the flash point, (4) the viscosity.

1. The corrosive sulphur test is carried out by keeping a sample of the oil at 100°C. for three hours with a strip of copper immersed in it. Discolouration of the metal indicates the presence of corrosive sulphur. This test is important since many bearing metals contain copper and their discolouration should be avoided.

2. The specific gravity of the oil is measured by a hydrometer; for normal practical use this test is of little value.

3. Flash point is the temperature in °F. at which a flash occurs when a small flame is applied to a fixed volume of oil, heated at a standard rate, in a closed vessel. The Pensky-Marten is the apparatus used. This test is over-rated as to its value by certain people; it is only a guide as to ease of ignition under certain conditions but in most cases it is valueless.

4. Viscosity is by far the most important single characteristic since it is the resistance to flow of the oil. Viscosity varies with temperature and it is its value at the working temperature which is important. It is normally measured by the time of flow of a fixed quantity of oil through an orifice or capillary tube.

With the Redwood viscometer, the time for the flow of 50 ml. through the orifice is measured but since the measuring cylinder is not kept at the same temperature as the body of the oil, this instrument only gives a relative figure. For engine oils a temperature of 140°F. is normally used and for cylinder and gear oils, 200°F. With the increasing importance of the knowledge of the variation of viscosity with temperature, the viscosity index has become important. This was an empirical scale using certain Texas oils as O and Pennsylvanian oils as 100. Other unknown oils could then be calculated.

A more accurate instrument than the Redwood was needed and so viscosity was measured kinematically by means of different sized capillary tubes, calibrations for which can be obtained by comparison with water. The temperatures normally used when measuring kinematic viscosity, are 100°F. and 210°F.

Engine or machinery oils are a grade of lubricant which may be termed 'general purpose' and is applied mainly by one of the following methods, (1) manual lubrication—intermittent application, (2) drip feed—continuous application at a controlled rate of oilfeed. (3) oil rings—continuous application, (4) splash feed or forced feed by circulation system.

To make the original selection of a suitable grade of engine oil, it is necessary to carry out a number of actual chemical and physical tests in order to satisfy the following conditions:

1. The necessary viscosity and the oil's ability to carry the bearing load without friction or overheating. The degree of viscosity needed depends largely on the size, speed, load, and temperature at which the machine will operate.

2. The resistance of the oil to oxidation and gumming. This is of extreme importance where lubrication is by circulating systems or oil rings.

Guide to Viscosity

As a general guide, with relatively high loading, speeds are often slower, and with the greater bearing clearances, the viscosity of the lubricant used tends to fall in the higher range. With high speeds, possibly lighter bearing loading and less clearance, the viscosity of the lubricant tends to fall in a somewhat lower range.

The bearings of high speed machines, or bearings normally operating under high temperature conditions, are generally water cooled, and in such instances greater care in the selection of the lubricant is necessary. In such cases it is often advisable to use a high quality turbine or crank chamber oil.

Steam cylinder oils. This range of oils falls into three distinct categories:—

1. Dark steam cylinder oil, suitable for comparatively

low steam pressures with moderately dry steam—or suitably compounded if the steam used is particularly wet.

2. Cylinder oil suitably compounded for superheated steam conditions, high steam temperatures or steam subjected to heavy condensation.

3. Highly refined steam cylinder oil mainly for use in high speed vertical engines.

Important Points

The functions of the steam cylinder oils are (a) to form a lubricating film between the piston and cylinder surfaces to eliminate metallic friction as far as possible, and (b) to seal any clearances to prevent undue steam leakage and so to maintain the maximum engine efficiency. It is vitally important that the rate of feeding the cylinder oil is correctly determined, since shortage of oil will cause excessive friction and wear and over-oiling will produce unnecessary carbonaceous deposits. The method of application too is important and this is best done by means of an automatic lubricator controlled by the speed of the engine. In all cases the cylinder oil must be atomised in the steam which thus becomes charged with oil vapour and ensures adequate lubrication. It is important that a high quality pure mineral steam cylinder oil is used in condensing engines, where the condensate or low pressure steam is used for steam raising or processing work. Under no circumstances should a compounded cylinder oil be used, since the compounding promotes the formation of an emulsion and the condensate can only be freed from oil by means of costly filters.

Pale or filtered cylinder oil should always be used for the cylinders of high speed vertical engines. This is because a certain amount of oil passing the rings may enter the crankchamber and a pale cylinder oil has much less effect on the demulsibility of the crankchamber oil than a normal dark cylinder oil would have. Viscosity is an important characteristic since too low a viscosity at the working temperature will not reduce friction sufficiently and will cause corresponding power losses; nor will too high a viscosity with poor atomisation lubricate efficiently.

Carbon residue or the amount of carbonaceous matter left when the oil is heated under controlled conditions is important. All valves, etc., on steam engines should be covered with a layer of lubricant and the carbon residue test gives a guide as to the quantity of deposit likely to be found on them. Two methods for carbon residue have been used.

1. The Conradson method, in which 5 g. of oil are heated in a special crucible so that it ignites in 10 mins. and burns for 13 mins. The residue is then weighed.

2. The Ramsbottom method, in which 1 to 4 g. of oil in a special bulb are placed in a lead bath at 550°C. for 20 mins. and the residue weighed.

Crank chamber and gas cylinder oils. These are linked together, since in general, the chemical and physical standards are such that a high quality lubricant can efficiently be used for both purposes. This is, in fact, the universal practice at most gasworks with which you are familiar. The tests I propose to discuss in this case, are:—

1. The effects of too high viscosity—oil starvation, particularly when cold or starting. Too low viscosity—the inability to carry the load as the oil would lack the desired film strength. Viscosity's influence on atomisation. The careful control of oil feed for gas cylinders since over-oiling will cause carbon deposits, sticking valves and rings, etc.

2. Flash Point. The importance for gas cylinder lubrication.

3. Demulsibility. This is probably the decisive factor for crank chamber oils. The effects of boiler water carry over, often aggravated by excessive quantities of water and/or steam cylinder oil are due to faulty scraper rings and separators not working correctly. The advisability of draining off free water from crank chamber as frequently as possible.

4. Acidity. Although the original oil is almost 'acid free' it can, by continuous circulation and air absorption, show an appreciable increase in acidity. The test is a direct titration against standard acid, after the acidic bodies have been allowed to dissolve in either alcohol, or a toluene isopropyl-alcohol mixture. Oils are of low acidity when new but continuous circulation tends to cause some oxidation and a rise in acidity. Any rise in acidity may, therefore, be taken as a simple test of oxidation.

1. Viscosity is important in that lubrication is normally by pump or splash. Too high viscosity might cause oil starvation particularly when cold or starting. Too low a viscosity will not carry the necessary load. The oil feed must be carefully controlled to gas cylinders since over-oiling can cause sticking valves and rings due to carbon deposits while under-oiling will not allow a complete lubricant film to be formed.

2. Demulsibility is probably the most important characteristic for crank chamber oils. This test is carried out by passing steam into 20 ml. of oil under such conditions that most of the steam condenses when 40 ml. of emulsion has been formed. The tube is removed and placed in a bath at a temperature of 200°F. and the time for the 20 ml. of water to separate noted. This period of time gives what is known as the 'demulsification number.' Free water should always be run off from the crank chamber regularly.

3. The measurement of acidity is one of the main laboratory tests to determine the necessity for changing the crank chamber oil.

Bearing Seizure

Turbine oils. The choice of a suitable lubricant for turbines is extremely important because of the speed at which they generally operate, and also because a very little wear can have serious effects on their efficiency. For instance, failure of the oil supply even for a short period can have disastrous results, and bearing seizure would be almost immediate. Similarly, in geared turbines where the gears are fed by a circulation system, a momentary stoppage of oil would be very serious. The conditions to which turbine oils are normally subjected are such that only the highest grade of oil should be used, as indeed the laboratory tests normally adopted will indicate. Apart from a few instances where turbines or turbo-driven boosters are installed, the majority of turbines used in gasworks are of the Greenwood & Batley geared type. In this particular type of turbine the gears and bearings are lubricated by the same forced feed system. Where these turbines are driving waste

heat boiler induced draught fans, the extension shaft bearings are water cooled and it is in such cases advisable to use the same grade of oil for the bearings as for the turbine.

Where larger turbines are driving generators or alternators, cases are known where the oil has failed because of electrolytic action, intermittently static, to the oil. It is not intended to enlarge on this particuar phase of oil failure since it does not fall under the normal requirements of the undertakings with which you are particularly interested. The general requirements of a high quality turbine oil are that it shall have (a) a suitable viscosity for the speed and loading, whether for a geared or direct driven machine, (b) freedom from acidity, (c) low demulsibility, (d) a very low tendency to oxidation and (e) be suitably inhibited against oxidation, rusting and foaming.

Regular Practice

As a general rule, where all other factors such as loading, temperature, etc., are equal, direct driven turbines use a light or medium turbine oil, but a similar geared machine needs a somewhat heavier grade. Where turbine systems are fitted with suitable oil storage tanks, it should be a regular practice to drain off any water which may have settled out. It is imperative, too, that sealing gland packings are maintained efficiently since this is undoubtedly the main means of ingress of condensate. Oil filters should be examined and cleaned regularly. Oil coolers should be cleaned both on the oil and water sides to ensure efficient cooling.

For larger turbine installations, a centrifuge should be available to remove grit, water, etc., from the oil to prolong its useful life. Oxidation, rusting and foaming tests are carried out on these oils.

In the oxidation test 100 g. of oil are placed in a vessel fitted with a reflux condenser and containing a piece of copper. The oil is heated in a bath at 110°C. and air (suitably dried) is passed through it at the rate of 2 l. per hour, for 90 hours. The acidity increase of the oil is then measured.

In the rusting test a rod of highly polished steel is suspended in the oil which is floating on a layer of brine. The oil and water are kept in emulsion by stirring at a temperature of 60°C. for 24 hours. The condition of the steel rod is then examined; it must show no sign of rusting.

In the foaming test air is blown through the oil in fine droplets and the amount of foam formed and the time taken for it to disperse are measured.

Gear oils and gear compounds. The main functions of gear oils or compounds for enclosed gears are briefly:—

1. The lubricant must have the necessary film strength to prevent undue friction and consequent wear of the teeth.

2. The oil must generally be of moderately high viscosity but, at the same time, sufficiently free-flowing to allow heat dissipation.

3. The oil must be of good stability and high resistance to oxidation.

The considerable number of different types of reduction gears and widely opposed operating conditions, make it frequently necessary to employ more than one single grade of gear oil in even a comparatively small undertaking. A typical gas undertaking's requirements may be gathered from a consideration of the types of gears in use and the conditions under which they operate in a gasworks. Such uses are:

1. Meter and exhauster gears.
2. High speed and turbine gears on large boosters and compressors.
3. Motor gears.
4. Enclosed gears, *i.e.*, conveyors, elevators, hoists, etc.
5. Coke extractor gearboxes.
6. Producer grate drives.

Lubricants varying from the pure mineral grades of very light viscosity to very viscous oils containing additives for extreme pressure conditions are needed to cover all these purposes.

Hydraulic oils. Hydraulic power transmission has become increasingly popular in recent years since it can be adapted to a wide range of purposes. The modern hydraulic system is at the same time reasonably simple, extremely flexible, and effective. Water, which was universally used as the hydraulic medium in the past, though possessing a very high fluidity and low compressibility, had certain disadvantages; for instance, the tendency to rust any ferrous materials and an almost complete lack of lubrication properties. Emulsions of soluble oil and water replace the water in many hydraulic systems, but such emulsions were only partially successful; hydraulic oils are now the generally accepted practice. Extremely fine clearances, precise timing and movement in modern hydraulic equipment and the necessity to avoid wear, demands the use of an oil with very carefully controlled characteristics. In addition to low volatility and pour point, a low compressibility and stability to oxidation, hydraulic oil must cause no rusting or corrosion. Many hydraulic systems have natural or synthetic rubber components so that hydraulic oils must be chosen which do not react with such materials.

Low Pour Point

If viscosity is too high, it will cause uneven operation, high frictional losses and heating up of the system, or if too low, it will fail to seal the fine clearances and cause slipping and loss of efficiency. Hydraulic systems must work over wide temperature ranges, so a low pour point is required to avoid pumping difficulties at low temperatures. The pour point is defined as the temperature at which the oil in a standard tube will just flow when cooled at a standard rate and allowed to stand throughout 5°F. temperature drops.

Rope oils. These oils are needed to form a protective film over wire ropes to prevent rusting and to lubricate the sheaves. It is thought to be unlikely that such oils materially assist in the lubrication of the strands of wire which move across one another in use. A bitumen type of lubricant is normally used for this purpose and the grade depends on the temperature conditions.

Exhauster oils. These serve the dual purpose of, (1) lubricating the internal moving parts and (2) keeping the exhauster blades free from tarry deposits.

A very careful blending of two entirely different base oils is needed. First, the blended oil must still possess lubricating film strength to take the loading, and

secondly, it must act as a detergent to prevent the deposition of tarry deposits. The simple mixing of two oils is not sufficient since not only can it prove ineffective, but crudely mixed, it can actually cause precipitation and oil starvation by blocking the lubricators and oilways.

Transformer oils are not strictly lubricants but act as coolants and insulators. Though viscosity, acidity and stability are very important, dielectric strength is probably the deciding factor. This is determined by building up a voltage of at least 30 kV across two terminals set .157 in. apart in the oil.

Lubricating greases. These are used at a great many points scattered throughout a gasworks and under widely varying conditions. There are instances, where bearings of high speed machines are found under conditions of heat, excessive moisture and corrosive liquors; grease cups or nipples may be fixed direct to the bearings or connected by pipes up to 10 ft. long; there are instances where graphite greases are necessary, or there may be extremely hot bearings such as coke extractor worm shafts. Special greases may be needed. These include H.M.P. grease, ball bearing grease—water resistant, soft grease for piped grease nipple points and graphite grease.

The tests normally of value for greases are:—

1. Dropping point, which is determined by heating the grease in a small rigidly standardised container at a fixed rate and noting the temperature at which the first drop of grease separates.

2. Penetration. The grease is held at a temperature of 25°C. for three hours and then worked in a grease worker. The grease is transferred to a special cup and the depth of penetration of a specially weighted cone is measured.

GAS ON THE CONTINENT

Deleterious Effect of Sulphur in Fuel

THE increasing use in Germany of oil firing and of American coal with high sulphur content has drawn more attention to the higher dew point of the flue gases due to the sulphur in the fuel. Fuel oil from the Middle East contains 2% S, but oil from Mexico as much as 3-5% S. Most of the sulphur forms SO_2, but a small portion of the latter is converted into SO_3, which forms sulphuric acid when combined with the water vapour of the flue gases. The presence of catalysts like CO, Fe_2O_3 and V_2O_5 promote the formation of SO_3, while Fe_3O_4, SiO_2 and soot hinder it. A dew point of 40 to 50°C. of a sulphur-free fuel oil is raised to 130°C. by a sulphur content of only 1%.

Dew-point measurements are usually carried out by determination of the conductivity of the condensate. As soon as the flue-gas temperature drops below the dew point the condensing sulphuric acid-vapour mixture attacks the heating surfaces of the boiler. The most common measure to eliminate this corrosion is to keep the air preheater and the economiser surfaces above the dew-point temperature, with a corresponding loss of thermal efficiency. Protective coats of a plastic or ceramic nature or alloy steels have not been satisfactory. Rapid cooling of the flue gases, whereby the H_2SO_4 forms an aerosol and can be carried away, have been successful in the laboratory, but has not yet been solved for practical use.

Added Attraction

Additives to the fuel have had promising results. Both dolomite and ammonia, which have been subjected to large-scale tests with satisfactory results, have the added attraction that they are easy to obtain and they are cheap. There is some discrepancy in the cost figures available from several power stations on the relative merits of the two chemicals. For the ammonia process it is claimed that an addition of 1.7 lb. per hour to a fuel oil with 3.35% S in a boiler of 10 tons per hour steam-generating capacity depressed the dew point from 133°C. to 50°C. It is expected that these two additives will gain ground and that this method will help to improve the efficiency of boiler plant with a minimum of expense.

G. Cerbe, *Gas-Warme* No. 7. July, 1958, p. 229.

LEAKAGE DETECTION

DISCUSSION—Concluded from p. 327

and found 12 minor leaks. Seven of the leaks were from the machines at the mainshaft glands, three from non-return valves at the operating spindle glands, one from a 4 in. valve gland and the last at a lubricator check valve on a main bearing housing.

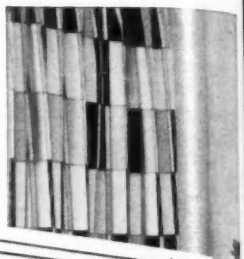
When repairing a main shaft gland, it should be borne in mind that the tightness of the gland is controlled by the rubbing speed of the gland packing on the shaft and the material of the packing itself.

Under certain conditions a slight leakage may be inevitable as further tightening may cause overheating and possible damage to the gland.

The scale deflection of the explosimeter is no indication of the size of the leakage and will largely depend on the proximity of the explosimeter probe to the source of leakage due to the diffusion of the gas into the air.

University of Leeds

AMONG donations and gifts acknowledged by the Council of the University of Leeds are donations totalling £4,705 to the Houldsworth School of Applied Science—£3,500 from the British Coke Research Association for research on liquor effluents; £500 from the British Coke Research Association for a Fellowship, and £795 from the British Ceramic Research Association for research.



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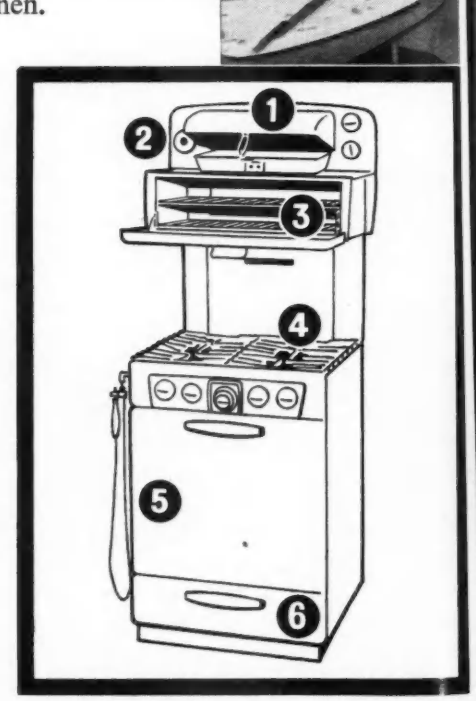


CASH PRICE £58.10.0

✳ OVERALL DIMENSIONS: HEIGHT 60¼", WIDTH 25½", DEPTH 22½"

Trade News

COMPLETE HEATING & HOT WATER

RECENT developments by Thomas Potterton Ltd., are designed to offer to the small householder complete heating and hot water equipment at a relatively low cost.

During the last three months a mobile display unit equipped with a complete range of Thomas Potterton products, including gas-fired automatic boilers actually in operation, has been touring the country, and special demonstrations have been staged for the benefit of heating engineers, architects, builders, and plumbers, with special sessions for representatives of the fuel industries and technical sessions for the installation staff.

On tour

The tour, planned to last six months, has now completed the southern circuit and the exhibition has been on view to the trade and general public in the showrooms of the De La Rue Company in Regent Street, London. The exhibition is now on tour in the northern half of the country.

One recent development on show is a Potterton unit consisting of boiler, circulating pump, magnetic valve, etc., in one complete casing for use with small bore heating systems.

The latest addition to their range, however, is a warm air unit. These units are ideally suited for inclusion in new houses under construction and it is intended that they shall be marketed with all necessary controls and accessories.

The heating of private residences has hitherto been largely dealt with by the traditional methods but an increasing demand in recent years has been for heating by the introduction of warm air. This method has been extensively used on the American continent for some time, but in this country only for large buildings such as theatres, department stores, assembly halls, industrial buildings and office blocks. It is only recently that a serious attempt has been made here to deal with the heating of private residences by warm air.

The Potterton warm air unit provides heating on the principle of transferring heat to circulated air through a hot water heated battery, in a manner similar to that used in the large-scale plants. It is of a size and price to enable warmth from a central source to be installed quickly, effectively and economically in the small domestic dwelling, whether of the bungalow type or two-floor layout.

Using water as a heating medium both the warm air unit and the hot water storage can be supplied from the one boiler. If used in conjunction with a Potterton low input copper indirect storage cylinder (max. heat input 12,000 B.t.u. per hour) a No. 30 Diplomat gas-fired boiler will be sufficient for moderate demands, whereas with a similar cylinder, plus the larger warm air unit, more extensive heating or higher temperatures can be provided from, say, a No. 44 Diplomat.

Concealed ducting

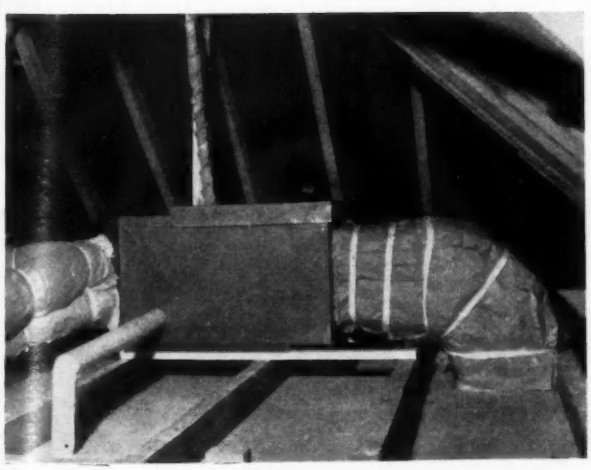
Among other advantages claimed are that the system causes the minimum of inconvenience to occupants of existing residences. Also there are no radiators or pipes to take up space since the air inlet grilles are flush fitting, and all the distribution air ducting is concealed within the roof or floor space, fitted cupboards, or panelled-in at convenient corners.

The system can be used in conjunction with any type of heating boiler but a Diplomat gas-fired boiler is recommended, and the introduction of warm air through the inlet grilles ensures comfortable conditions together with unobtrusive air movement. With the heating circuit closed down, the unit may be used during summer months to promote air movement, thus giving a cooling effect, meanwhile leaving the boiler in operation for the hot water supply. The makers also claim that discolouration of decorations is avoided by the incorporation within their system of an air filter which ensures clean air being delivered through the inlet grilles. Provision can also be made for the introduction of fresh air.

Gravity circulating

Two units, the Minor and Standard, are designed to operate with a gravity circulation and are generally intended for bungalows, houses or flats, where the unit is situated either in the roof space or at high level on the ground floor. They can, however, be used for small suites of offices, shops, workrooms, etc.

The Minor unit has a duty of 200 cu.ft. per minute, and a heat output of approximately 17,000 B.t.u. per hour, while the Standard unit has a duty of 300 cu.ft. per minute and a heat output of approximately 25,000 B.t.u. per hour. The maximum working head for both units is 20 ft. The maintenance of either unit is very little and simple to carry out.—*Thomas Potterton Ltd., 20-30, Buckhold Road, London, S.W.18.*



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A Potterton warm air unit installed in a typical loft.

★

Hedgehog takes up the dirt silently

B.V.C., well known to industry as the manufacturers of all types of equipment for suction cleaning and to the gas industry as makers of built-in pneumatic plant for the removal of dust and dirt from retort houses, have lately entered the field of floor maintenance equipment manufacture.

At a recent demonstration to the Press, models capable of undertaking every task connected with floor cleaning were on view, including scouring, scrubbing, floor-drying, polishing and carpet shampooing. These electrically-driven machines can be used for any large floor-cleaning work from the gas showroom to the canteen or the maintenance workshop. Journalists were shown soiled linoleum taken out of the firm's canteen and swiftly cleaned and polished in two easy operations with the help of a mains operated polishing machine.

For large showrooms with tiled floors, the Musquash wet scrubbing, mopping, dry cleaning and floor polishing machine, in conjunction with the Ferret floor dryer to take up the dirty soap suds after wet scrubbing, can be used effectively. For

canteens with linoleum covered floors, where dry cleaning alone is needed, the 'Musquash' by itself is enough.

For heavy industrial work, such as the scouring of workshop floors of wood or concrete, the Hedgehog fitted with spring steel wire brushes will effectively remove dirt for which it would normally need a hammer and chisel to dislodge.

Mains or battery

The Hedgehog is made as a mains or battery driven model. Provision of the latter makes possible its application where an electric lead would be a nuisance and allows greater freedom of movement among machines and other obstacles normally permanently fixed to workshop floors. Batteries add weight to the machine, a further advantage where heavy work is being undertaken.

Those models used for wet cleaning, including floor drying machines, are fitted with light plastic tanks to hold the detergent solution or to store the dirt lifted from the floor prior to disposal. All models are very silent in operation and cause no vibration.—*The British Vacuum Cleaner & Engineering Co., Ltd., Goblin Works, Leatherhead, Surrey.*

A B.V.C. Hedgehog battery model at work.

Main greets 1959 with new de-luxe refrigerator

NEW for 1959 is the Main No. 36c., an absorption type de-luxe gas refrigerator by R. & A. Main Ltd.

Precision finished throughout, and designed to give a lifetime of silent, efficient and trouble-free service, the No. 36c. carries a ten-year guarantee on its sealed cooling unit.

Available with white or cream exterior cabinet it retains the distinctive appearance of previous models—the cabinet top is gently curved and the shaped door, complete with maker's motif, has a chromium plated pull-down handle. The interior has been greatly enhanced by the use of coloured vitreous enamel in an attractive shade of shell pink with matching breaker strip, coral red trims and anodised gold door shelf rails.

Extending across the full width of the top of the liner, the frozen food compartment is fitted with a spring loaded self closing door. Designed to make ice in room temperatures of up to 95°F. (35°C.), the compartment contains three ice trays with flexible dividers and will take about 4 lb. of frozen goods plus ice, or approximately 6 lb. of frozen food with the ice trays removed.

The 36c. refrigerator by R. & A. Main Ltd.

With 3.6 cu.ft. capacity and 7.7 sq. ft. shelf area, the No. 36c. provides really generous storage space. Three full width shelves and one smaller shelf, all finished in bright chromium are fitted, and the base of the liner acts as a fifth shelf. The door interior provides further storage—two shelves for milk, fats and small bottles and a recessed rack for eggs. Two covered containers for meat, fish or salads are also supplied. An unrefrigerated space of 1.5 cu.ft. in the base is available for storing canned food and dry goods.

Automatic temperature control is achieved by means of a fluid expansion type thermostat which can be adjusted to suit room conditions, the control knob being conveniently positioned in the centre of the top breaker strip.

Defrost control

A defrost control is also provided, this being incorporated in the gas on/off tap situated in the plinth base. A flint lighter is also fitted.

Brief specifications are as follows:

Refrigerating Unit.—Absorption type, maximum input 1,000 B.t.u. per hour.

Temperature.—The unit and cabinet are designed to make ice in room temperatures up to 95°F. (35°C.).

Thermostat.—Fluid expansion type; control knob at top of cabinet.

Gas Connections.—$\frac{1}{8}$ in. B.S.P. male or $\frac{1}{4}$ in. B.S.P. female. The supply is governed to eliminate variations in mains pressure.

Defrosting.—Gas control tap has a defrost position.

Levelling Device. — Four levelling screws are fitted to ensure correct alignment.

External Dimensions:

Height 46$\frac{1}{4}$ in.; width 24$\frac{1}{2}$ in.; depth 24$\frac{3}{4}$ in.

Depth, including handle, 26$\frac{1}{2}$ in.

Depth, including door swing, 45$\frac{1}{2}$ in.

—*R. & A. Main Ltd., 48, Grosvenor Gardens, London, S.W.1.*

GRIFFIN GROUP EXPANSION

GRIFFIN & GEORGE (RESEARCH & DEVELOPMENT) LTD., has been formed by the Griffin & George Group to conduct research into, and develop, new and improved scientific instruments and apparatus for laboratory use and process control.

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